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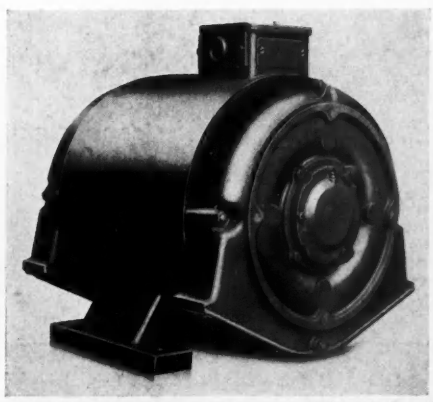

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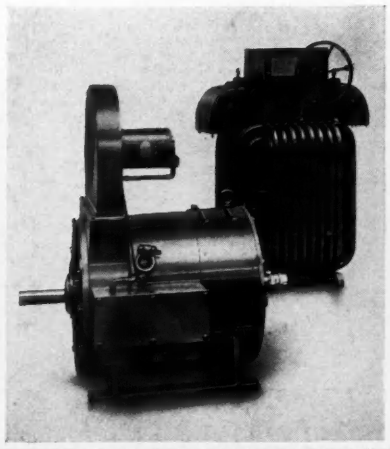

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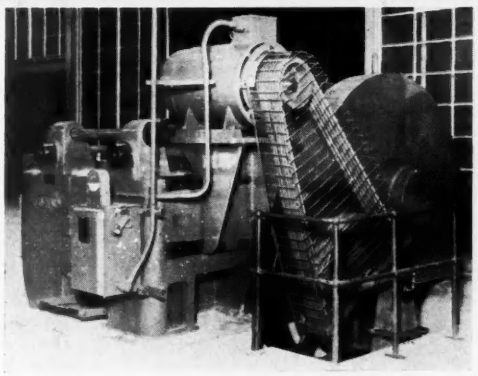

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A Seven-Day Journal

Jubilee of the City and South London Railway

MONDAY, November 4th, marked the jubilee of the official opening of the City and South London Railway by King Edward VII on November 4th, 1890. Tunnelling operations for the construction of the tube railway from Stockwell to King William Street were begun in 1886 under the direction of James Henry Greathead, who was appointed engineer for the undertaking. In that work use was made of Greathead's excavating shield which still finds use in London's underground work. Progress was made at a rate of about 80ft. per week, and by June, 1887, the tunnelling had been completed. It was originally intended to work the railway on the cable principle, but the company decided on a bold experiment and the City and South London became the first electric tube railway. At the time it was opened the line was about 3 miles in length, but at later dates it was extended. In 1900 the extension to Moorgate was opened, and in June of the same year the line was carried southward to Clapham Common. It was extended northward again in 1901 to the Angel and to Euston in 1907. The original size of the tunnels was 10ft. 6in., compared with the standard underground diameter of 11ft. 8½in., and that retarded progress. In 1913 the line was amalgamated with the Underground Group and was reconstructed between 1922 and 1924. All the original stations were enlarged and rebuilt, and the tunnels were increased in diameter in order to accommodate more roomy rolling stock. New tunnel connections were made at Camden Town and Kennington, enabling through trains to be run from Highgate in the north to Clapham Common in the south. In 1926 the line was again extended from Clapham Common to Morden, and a further short link between Kennington and Charing Cross was opened which gave a through route to the West End as well as to the City and the North of London. One of the original electric locomotives, built by Mather and Platt, Ltd., and Beyer Peacock and Co., Ltd., in 1890, for the City and South London Railway is preserved in the Science Museum at South Kensington, and another may be seen at the Moorgate Station of the Metropolitan Line. The locomotives have a length of 14ft., a breadth of 6ft. 9in., and a height of 8ft. 6in. The weight is about 12 tons. Each motor is rated at 50 B.H.P., and there is a motor on each of the axles. The tractive effort was about 3000 lb., with a current of 226 amperes, and 40-ton trains could be hauled at an average speed of about 12 m.p.h., the maximum speed varying from 20 to 25 m.p.h.

Mossfield Colliery Explosion Report

THE Mines Department has just issued through the Stationery Office the report of Mr. F. H. Wynne, H.M. Chief Inspector of Mines, on the causes and circumstances attending the explosion which occurred at Mossfield Colliery, Longton, Staffordshire, on March 21st this year. Eleven men, it will be recalled, perished from injuries which were caused by the explosion, which took place in the Cockshead seam of the colliery. That seam gives off firedamp so freely that only safety lamps and permitted explosives are allowed to be used in the working. The seam has had an unenviable reputation, and from its earliest days the workings in it have been dogged by troubles arising from spontaneous heating. On October 16th, 1889, fifty years ago, an explosion, initiated by a gob fire, caused the loss of sixty-four lives, and considerable portions of the workings have been sealed off at different times on account of gob fires breaking out. On account of the liability to gob fires, special methods of working were adopted, and, except for the accident in 1889, have been substantially successful until the last unfortunate occurrence. The effects of the recent explosion would have been greatly magnified, but for the fact that the roadways were copiously treated with stone dust. As it was, the explosion was limited, both in its extent and its violence. The explosion occurred shortly after 1 a.m. on Thursday, March 21st, in the third hour of the night shift of Wednesday to Thursday, March 20th to 21st. At the time there were twelve persons, including the fireman, at work in and near the level face. All were killed or severely injured by the explosion, and only one, the fireman, survived. In the report, the Chief Inspector reviews the events leading up to the explosion and those immediately subsequent to it, and states that the general scheme or lay-out of the colliery calls for no adverse criticism, but appears to be admirably adapted to present-day methods of machine mining and the physical conditions of the seam. The air system of the face is discussed, and the Inspector states that there is a possibility that the explosion would not have occurred if a pack had been constructed about double the width of the heading. No allegations of breaches of statutory requirements were made at the inquiry, and none was revealed by it. The report concludes with the Inspector's observations as to those measures which might help to prevent a similar occurrence in the future.

British Naval Losses

ON Monday, November 4th, the Board of Admiralty announced with regret the torpedoing and sinking by enemy U-boats of the armed merchant cruisers H.M.S. "Laurentic" and H.M.S. "Patroclus." The reports so far received indicate that the following numbers of survivors have been rescued by H.M. ships :—H.M.S. "Laurentic," 53 officers and 316 ratings, and H.M.S. "Patroclus," 33 officers and 230 ratings. The "Laurentic" was formerly a White Star liner engaged in the company's Canadian service, and she was the second vessel to bear that name, the first being the "Laurentic" of 1909. The "Laurentic" was completed in 1927; like her predecessor, she was built and engined by Harland and Wolff at Belfast. She had a gross tonnage of 18,700 and a sea speed of about 16½ knots. Her length was 600ft. The propelling machinery comprised a three-shaft arrangement of combined reciprocating engines and steam turbines. Each of the wing shafts was coupled to a four-cylinder, triple-expansion steam engine exhausting into a low-pressure turbine on the centre shaft. Steam was supplied by four double-ended and four single-ended boilers. The "Patroclus" was formerly in the fleet of the China Mutual Steam Navigation Company, Ltd., managed by Alfred Holt and Co. She was built by Scotts Shipbuilding and Engineering Company, Ltd., at Greenock, in 1923, and had a gross tonnage of 11,314. Her length was 498ft., with a beam of 63ft. 4in. and a depth of about 26ft. Her propelling machinery comprised a twin-screw arrangement of single-reduction steam turbines, taking steam from oil-fired boilers. In connection with the sinking of these two ships so soon after the loss of the "Empress of Britain," the Admiralty has announced the sinking of two German U-boats during this period, one of which was responsible for the sinking of the "Empress of Britain."

Germany's Air Losses in London Attacks

AN announcement made by the Air Ministry on Saturday, November 2nd, stated that during the past twelve weeks of attack on Great Britain the German Air Force has lost three aircraft and fourteen airmen for every one of ours. Since August 8th, when the first big air battle was fought around our coasts, fighters, gunners, balloon barrage, and other causes have accounted for 2433 German bombers and fighters. Of that total, bombers and fighters have been destroyed in almost equal numbers. The most severe blow which the Fighter Command has dealt to the Luftwaffe has been the loss of trained airmen. If the usual number of pilots, observers, and air gunners to the various types destroyed be allowed, over 6000 German airmen have been killed or taken prisoner, while the Fighter Command has lost only 353 pilots. The weekly figures reveal a gradual weakening of the German effort in spite of continuously changed tactics. On August 8th three mass dive-bombing attacks were made on shipping convoys and harbours. The Nazis lost 24 of their famous Junkers 87 dive-bombers and 36 Messerschmitt 110 and Messerschmitt 109 fighters. Seven days later 1000 German bombers and protecting fighters launched the biggest attack in the history of air fighting. Their objectives were harbours and R.A.F. aerodromes. At the end of that day the Germans had lost 180 aircraft and during that one week they lost 472 bombers and fighters, which still remains a record for seven days' fighting. That week their bomber losses were 234 against 162 of their fighters. Of those 234 bombers, 161 were dive-bombers—Junkers 87 and 88s. From then onwards the Germans changed their tactics. The use of the Junker dive-bombers—hitherto claimed to be Germany's most deadly weapon, but quickly mastered by our fighters—has been gradually abandoned. During the second week in September only two Junker 87s were shot down, and since then they completely disappeared until a recent convoy raid. Even Junker 88s—the Nazi's newest type—have only been coming over in small numbers. But the more or less complete abandonment of the use of bombers for day raiding did not take place until the end of September. On September 7th the Germans opened their blitzkrieg on London. They lost 103 aircraft in that battle. On September 15th the Luftwaffe made another more desperate attempt to crush Fighter Command defences. But in that attack the Germans lost 185 aircraft, and the Fighter Command achieved a new record for a single day's fighting. On September 27th the Germans made one more big effort—their last. They increased the proportion of fighter escort to four to one. But still they lost 133 aircraft, of which 91 were fighters. Because of the high cost of this form of air warfare the Germans again decided to change their tactics. Bombers visiting these shores during the day time are now few and far between. In their place the high-flying Messerschmitt 109 fighters carrying only a small bomb load are now used. The Fighter Command is now defeating this menace. On October 7th fighters shot down 27, of which 21 were Messerschmitts and on Tuesday, October 29th, 33 were destroyed.

Engineers' Wages

AT a meeting of the Engineering and Allied Employers' National Federation, which was held in London on Tuesday, November 5th, Sir Alexander Ramsay, the Director of the Federation, replied to the claims of the engineering trade unions for an increase in wages, and announced that the employers could not accede to the applications. Giving reasons for the decision of the employers, Sir Alexander said that in the main the objections to a further increase in wages were based on broad grounds of national policy. In support of the employers' view, Sir Alexander produced a table of actual earnings in the engineering industry and another table which showed the comparative earnings of engineering workers and those employed in other industries. The tables showed that engineering workers are not in a disadvantageous position. In the table of earnings in the engineering trades, it was shown that skilled men who are working 5½ hours longer a week are earning on the average 28s. a week more; semi-skilled men working the same number of additional hours, 24s. a week more; and labourers working rather less than five hours longer a week, 16s. a week more. These calculations include the 5s. increase in wages given in February last. It may be recalled that the Amalgamated Engineering Union and the National Union of Foundry Workers had asked for an increase in basic rates by 3d. per hour, or approximately 12s. a week, while the Joint Trades Movement of the Engineering Unions, which compose the Confederation of Shipbuilding and Engineering Unions, had presented an independent claim for an additional 10s. a week. The Amalgamated Engineering Union had also asked for a restoration of working conditions which they surrendered nine years ago. The final character of the employers' reply to these demands was unexpected by the leaders of the unions, and it is understood that a meeting of all the executives of the unions in the Confederation is to take place in York on Tuesday, November 19th. The Executive Committee of the Amalgamated Engineering Union is to discuss the situation at an early meeting, and there is a possibility that the union's National Committee may be summoned.

G.W. and L.M.S. Railway Accidents

IT is with deep regret that we record one of the most serious railway accidents of recent years, which occurred on the Great Western Railway in the early hours of Monday morning, near Taunton, not far from Norton Fitzwarren. The disaster took place about 4 a.m. on Monday morning, when the 9.50 p.m. express from Paddington to Penzance was nearing Norton Fitzwarren. The train was crowded, and twenty-seven people were killed, and fifty-nine injured, twenty of them seriously. The death roll is the largest in any railway accident during the past three years. It has been officially stated that the cause of the derailment was a pure accident and was not the result of enemy action or sabotage. The investigation into the cause cannot be completed until the *débris* has been cleared from the line, but this work was started immediately, and single-line working was resumed on Monday evening. The locomotive plunged on its side, and the first four coaches of the train were telescoped. The rails over a small culvert had given way, and one of the coaches had sunk into the water and mud for several feet. The fireman of the express was killed by being trapped under tons of coal, but the driver was able to climb from the wrecked cab and ran to the station at Norton Fitzwarren, where the signals were set at danger. Messages were at once sent to Taunton, and doctors and ambulance workers immediately hurried to the scene of the accident. Rescue work was carried out under great difficulty, and after working throughout the morning, the breakdown gangs were able to recover twenty bodies from the wreckage, which were taken to Taunton. On Tuesday evening, November 5th, it was announced by the London, Midland and Scottish Railway Company that a serious accident had taken place in the south of Scotland, near Gretna, on Tuesday, when the 10.5 a.m. passenger train from Euston to Perth came into collision with a goods train. The accident occurred in the darkness. The passenger locomotive was overturned, and two coaches were telescoped on to the wreck. The rear part of the train remained on the rails. It is reported that the driver of the passenger train was killed and a number of passengers injured, about sixteen seriously.

Further North American Locomotive Experiences

By EDWARD H. LIVESAY

No. V

(*Continued from page 278, November 1st*)

"THE PACIFIC LIMITED," CHICAGO AND NORTH-WESTERN RAILWAY

IT is safe to assume that the builders of the earliest locomotives—Trevithick, Hedley, Stephenson, Hackworth—were very little interested in speed *per se*. Increased haulage capacity over the horse was what they were chiefly aiming at. Probably it was the Rainhill trials and the velocities attained thereat by the "Novelty" and "Rocket" that first opened the eyes of engineers to the possibilities of fast travel latent in the locomotive, and demonstrated—much to their surprise, no doubt—that unexpectedly high speeds could be attained on rails with safety by improved engines built with this end in view. The Voice of History has spoken—their confidence was justified, since within a short period locomotives were running at 60 m.p.h. in everyday service, and even higher speeds soon became commonplace.

At that time, and subsequently, it was accepted as axiomatic that driving wheels of large diameter were essential for fast running, but that they could only be employed by sacrificing haulage capacity. To a certain extent, of course, this is still true of the basic design of locomotive. Granted high speeds can be attained by the small-wheel engine, but only at the expense of increased wear and tear to engine and track; in fact, "a short life and a merry one" is likely to result if piston speed becomes too high, and driving wheel revolutions too dizzy. But times have changed somewhat, and in Great Britain, the original home of the big-wheel engine—and super-big, nowadays all the fastest work is done with wheels 6ft. 6in. to 6ft. 9in. in diameter, and, thanks to improved valve gears, easier steam flow, &c., far higher speeds have been reached than ever were within the scope of the older type of engine. In America, however, where comparatively small wheels were formerly favoured, it is possible to argue an opposite tendency; larger wheels seem to be coming into favour there for high-speed work, the engines still retaining great tractive power by the use of the booster, and so on. It is with an outstanding example of this development that the present article is concerned—the 4–6–4 type express engines with 84in. driving wheels running on the Chicago and North-Western Railway. My observations were made while on a return trip from Chicago to Clinton with the "Pacific Limited," during which 276 miles were covered; trips which left me with the highest opinion of these striking engines. My locomotive experiences during the last couple of years have brought me into association with many fine machines, but none has impressed me more favourably than these admirable examples of the latest American locomotive practice.

A little explanation is necessary about the trains on which the engines are employed. There seems to me to be a fundamental difference between express trains in England and America. In Great Britain they mostly serve the larger centres, intermediate towns being dependent on stopping trains which act as "feeders" to the expresses. In America—at all events in less thickly populated parts—the expresses stop at quite small towns and "feeder trains" seem few, or even non-existent. To illustrate this, if I wanted to go from Wolverton to Glasgow I should probably take the best train available to Crewe, and change there into, say, the "Mid-day Scot," which would only make three stops in the remaining 244 miles to the Scottish terminal point. But if express trains in England behaved as they do in America, the "Mid-day Scot" would stop at Wolverton to pick me up and subsequently would pause in its flight to the North at Blisworth, Weedon, Rugby, Nuneaton, Tamworth and a number of little jerk-water towns as well, making at least thirty stops instead of three. Of course, to English ideas it would not be an express train—it would be an exasperation. But that is how many expresses in America act, including the "Pacific Limited"; candidly, I don't know exactly what constitutes an express in America. In all this I am ruling out the Diesel flyers and super-trains, such as the "Twentieth Century" and the like, which do behave in a more legitimate manner. But it follows from the foregoing that an American express engine must have (1) speed, (2) power and (3) rapid pick-up, or it cannot do the strenuous work demanded of it. Hence the 7ft. wheels, 55,000 lb. tractive effort and booster of the "E 4" class, 4–6–4's on the Chicago N.W.R., with which this article deals; they may be called upon to handle "stopping expresses" of 1500 tons, running up to 70 m.p.h. between stations quite close together. The long non-stop runs so common in England are unknown in America, where expresses are fewer and much heavier, and stop frequently at way-points out of which, were they in England, the "Coronation Scot" would make its wash-pot, and over which it would cast out its shoe.

To pass from generalities to the particular, space limitations prevent a detailed description of the "E 4" class engines. I can only draw attention to some of the chief features, and the dimensions will be found in the table below. The generous heating surface, 5863 square feet, 300 lb. pressure, the 90·7 square feet grate, two siphons, arch tubes, and combustion chamber, are points worth noting, coupled with a boiler 7ft. 10in. in diameter, all of which guarantee an ample steam supply for the 25in. by 29in. cylinders. The valve travel is 7¾in., lap 1⅞in., lead $\frac{3}{16}$in., and exhaust clearance ⅛in. All the axles have roller bearings, and the lubrication system is very thorough. It includes a forced supply to points such as the horn blocks, bogie pivot, and trailing truck anchorage. The motion is light, particularly the crossheads, and engine balance—which embodies cross balance, too—has received special attention. Fittings include the usual multiple-throttle, low-water alarm, and an exhaust steam injector, which was used because (quoting Mr. Michael, the designer) "it is lighter than either the closed or open type feed-water heaters generally used; the limited space available practically excluded these, and both first and maintenance costs were considerably less." Three headlights are fitted—main, emergency, and "Mars," the latter being of the swivelling type described in "The 400" diesel article, No. II of this series. It is the lowest of those to be seen in Fig. 8. Automatic cab signalling is installed, as described recently in THE ENGINEER, and the tender has a coal pusher to bring the fuel forward to the stoker conveyor. The total weight is 346 tons.

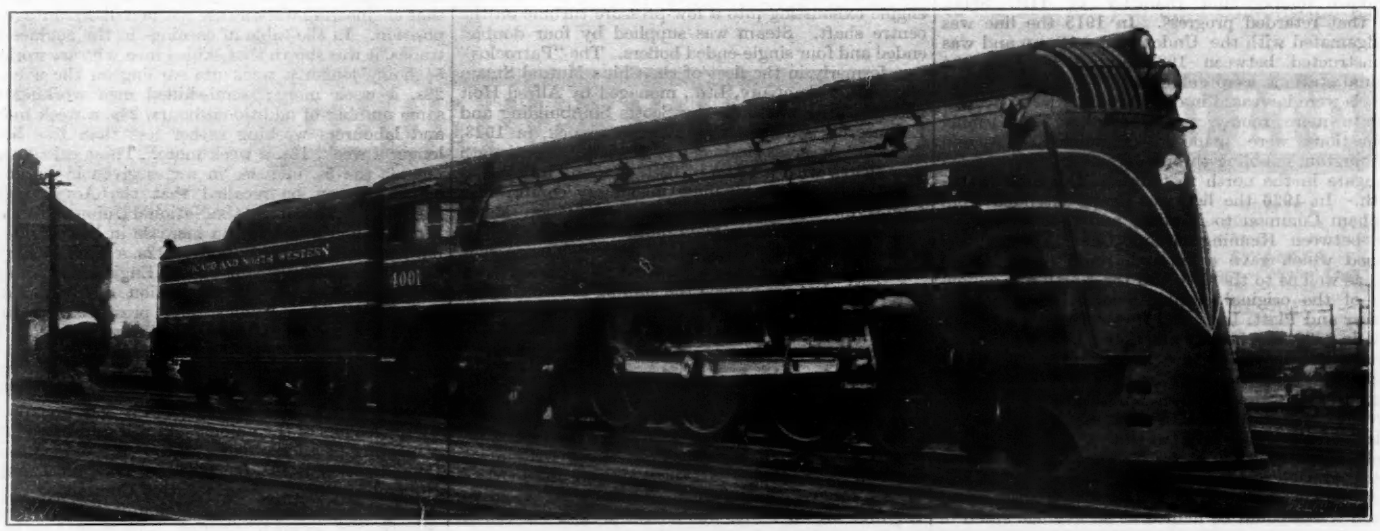


FIG. 7—"No. 4001" 4-6-4 EXPRESS LOCOMOTIVE—CHICAGO AND NORTH-WESTERN RAILWAY

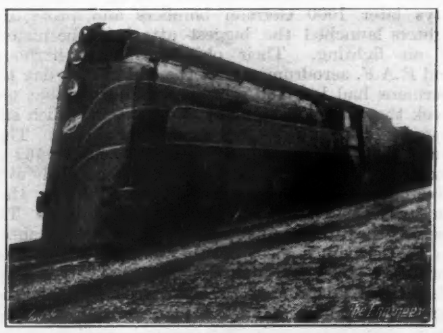


FIG. 8—HEADLAMPS OF LOCOMOTIVE

Particulars of "E4" Class Engines

Steam pressure	300 lb.
Tubes	8—2in.
Flues	196—3½in.
Grate area	90·7 sq. ft.
Stoker	Standard type B K
Coal pusher	Slope sheet, type D-A
Low water alarm	Barco, type F-3 A
Valve gear	Baker
Tractive power	55,000 lb.
Factor of adhesion	3·93
Width over streamlining	10ft. 10¾in.
Minimum curve	20 deg., or 288ft. radius
Heating surface:	
Tubes	79·0 sq. ft.
Flues	3,393·0 sq. ft.
Arch tubes	21·0 sq. ft.
Siphons	119·0 sq. ft.
Fire-box and combustion chamber	367·0 sq. ft.
Total	3,979·0 sq. ft.
Superheater	1,884·0 sq. ft.
Weights:	
Truck loaded	87,000 lb.
Trailer loaded	109,000 lb.
Drivers loaded	216,000 lb.
Engine loaded	412,000 lb.
Tender loaded	360,000 lb.
Engine and tender loaded	772,000 lb.
Engine light	373,000 lb.
Tender light	150,000 lb.
Engine and tender light	523,000 lb.

I have drawn attention in previous articles to the greater latitude enjoyed by American engineers with their more generous loading gauge. The maximum height of these engines is 16ft., the width 10ft. 10¾in., width inside the cab 10ft. 9in., and the height to boiler centre line also 10ft. 9in.

Mr. Michael, the C.M.E. of the Chicago N.W.R., kindly accompanied me during an inspection of these fine engines at the Chicago Kinzie Street sheds, explaining many interesting features. He mentioned that the roller bearings had given no trouble, and that 300,000 miles have been run before the crossheads needed rebabbitting; the guide bars have forced lubrication; 225,000 miles were covered before the tires were turned, which speaks well for the balance, among other things. The floating bushes on the connecting-rods do 80,000 miles before they need attention, and individual engines have run 350,000 miles within two years.

I noticed another striking example of Mr. Michael's designs at the shed, the 4–8–4 type, used chiefly in heavy freight traffic; but, unfortunately, time did not allow me to make a run with it. These engines have the "Woodard" side rod arrangement, which I have always thought highly of, but Mr. Michael said it was only suitable for freight work, as it is heavy, and tends to overheat in high-speed running. He would never employ it again for expresses. So another of my idols is, if not shattered, somewhat bent.

The "Pacific Limited" runs daily from Chicago to Seattle, 2446 miles. I did not go quite all the way with it—138 miles to Clinton, the first divisional point. It is a double-track route out of Chicago, the train running on the left-hand metals. I believe the C. and N.W.R. is the only line in America to follow this rule, but the engineer sits on the right of the cab, as usual. It reminded me of the G.W.R. and other "right-hand-drive" engines in England. Broadly speaking, there is a steady rise of 240ft. in the first 58 miles to sinews of war. British railways have to pay their way—American railways do not.

The "Pacific Limited" pulled out at 11.35 a.m., O.T., with fifteen cars, a load of about 1200 tons; the throttle was opened very cautiously and slight slipping—quickly checked with sand—occurred on the sharp curve just outside the depôt. The factor of adhesion, by the way, is 3·9, a little on the low side. As "No. 4004" got going the throttle was opened progressively to two-thirds at 15–20 m.p.h., when the exhaust pressure was 10 lb. and superheat 700 deg. Fah. Acceleration was good, in spite of the considerable load; but, of course, the booster had helped in the get-away. A one-minute stop at Oak Point was made at 11.50, the 9 miles having taken fifteen minutes. The restart coincided with a straight track; here there was no slipping and the pick-up was rapid, notwithstanding the 7ft. wheels. The exhaust pressure was 10–15 lb., the boiler figure being 280 lb.; the latter is always easy to hold with mechanical stoking. The track was largely unfenced and gradient crossings were often ungated, to my disquiet, as was described in the diesel article—I don't like it. The speed rose quickly to 70 m.p.h., the permissible limit; if this is exceeded, "yea, but a little," a horn sounds in the cab and the brakes go on automatically. The riding was "very good; takes curves admirably," according to my notes, and the balance was so perfect that the working parts were imperceptible, to my pleasurable surprise, as I had expected those 25in. cylinders to give plain evidence of their existence. Nosing was unobtrusive and rolling easy and very moderate.

speed, the crew apparently believing this to be ultra-modern, and typical of American time-saving methods. I flattened them out by mentioning that it had been done in England since long before I was born, and I am no chicken either. Had I been undiplomatic I might have poured scorn on the way mail bags are dropped in America; they are literally dropped; merely chucked off. If the bag should get under the wheels—well, I guess it would be just too bad for the mail, and that's that.

It was almost level country here, very green and fresh this pleasant May day, and the track was straight for considerable distances. Again the 70 m.p.h. warning horn sounded; it was beginning to get a little on my nerves, like a check rein on a horse. I should have liked to see what those 7ft. wheels could do at a pinch; it seemed such a pity to waste them. Another stop—Rochelle, time 1·11, restart 1.13. Rochelle is so diminutive that it does not even appear in the timetable, yet the "Pacific Limited" halted there. Why "Limited"? Echo answers "Why?" I cannot—unless it be that the average speed is severely limited by the numerous stops!

No trouble was caused by steam blowing down over the windows, the combination of streamlining and the air collecting grid being effective. The gradients in places were quite heavy, but I had no gradient book, so cannot give them. After getting well away from Rochelle, suddenly the air signal from the conductor sounded, and "No. 4004" came to a quick stop—a passing train crew had noticed smoke coming from under one of our cars and had called our conductor's attention to it. A hot box? No. Investigation showed it to be a

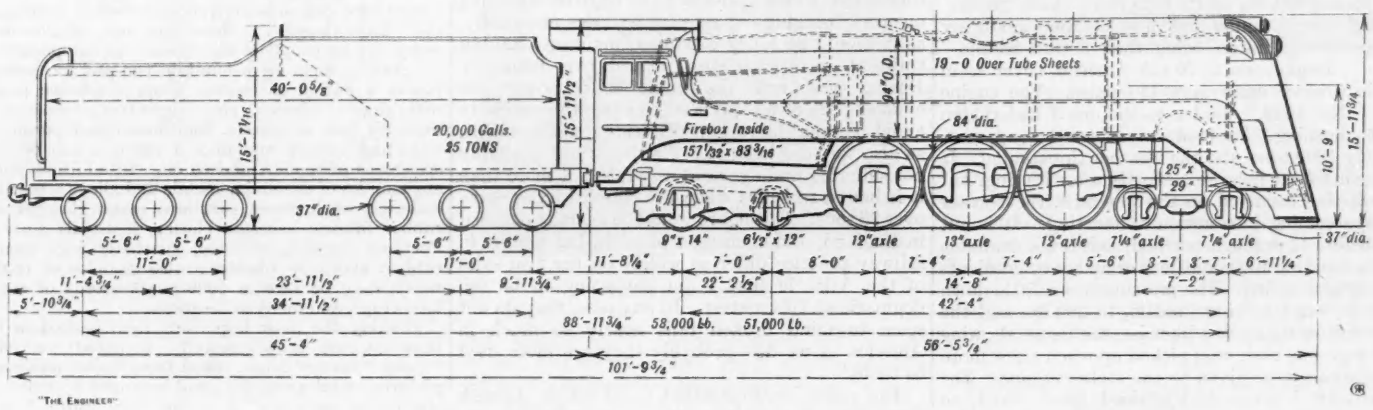


FIG. 9—DIAGRAM OF 4-6-4 TYPE EXPRESS LOCOMOTIVE

De Kalb, after which the track falls 286ft. in the succeeding 80 miles to Clinton.

Climbing into the cab of "No. 4004" at Madison station, I sensed a somewhat heated atmosphere, the combined radiation from the fire-box and Engineer Kinne, who was fighting with the steam-heat valve, which had stuck. The battle won, I introduced myself and was soon made to feel at home, Fireman Moseley being quick to assure me that he was not even remotely connected with Sir Oswald of that ilk—the latter had just been interned. I congratulated him on this. The cab and its fittings were much as usual, but it was open backed, so I was prepared for more noise than is heard in the Canadian vestibule type, or say, the "A 4" L.N.E.R. pattern in England. Looking round the engine before train time, I noticed a depressing plate on the side, worded somewhat as follows:—"This locomotive is the property of the Central Hanover Bank and Trust Company, Owner and Lessor, Equipment Trustee." The explanation of this is that many American railways are in the hands of receivers, and apparently the C. and N.W. is one of them. Immense sums have been provided by the Government to keep them in operation, and to finance new equipment, which results in a paradox—the more broke an American railway is, the more it can spend on fine locomotives, diesel streamliners, and up-to-date material of all kinds. But the taxpayer foots the bill! If he did not, there would be mighty few of the super-trains and locomotives one finds in America to-day, and thousands of miles of rusting and abandoned track would tell the tale of victorious road transport. It would seem that America has gone a long way towards the nationalisation of railways. British railway enthusiasts can take heart of grace; the apparent conservatism and slow progress on English lines is in no way due to absence of technical knowledge or skill; it is because they lack the backing of a bottomless governmental purse to provide the

The Geneva stop was made at 12.18, so the 26 miles from Oak Park had been covered in 27 min., at an average of 57·8 m.p.h.; the restart was at 12.23, O.T. All the gauges showed by this time that the engine had warmed through and that the fire was in good running shape; the grate had been rocked twice since leaving Chicago. There is a heavy up-gradient out of Geneva, which was taken with two-thirds throttle; it was followed by a dip and another rise on a long, straight stretch, giving a switchback effect. Here we overtook and passed a long freight train with scores of hoboes (*Anglice:* tramps) sitting on the roofs, enjoying the scenery and warm sunshine; others were lounging in the open doors of the box cars or were draped over agricultural machinery on the flats. Why are they allowed to do this? They are not—but they do it, nevertheless! This was America, the home of the brave, and the land of the free. It would cost more to maintain a staff to kick them off than the job would be worth. Besides, it would be mighty dangerous for the staff. "Hell, let 'em ride!"

It was breezy and pleasant in the cab, that warm, sunny day, but Kinne said it could get very hot in summer, which I should think must be due to the openings in the lagging opposite the hollow stays. The water jar was often in demand; it nestled in a locker, cuddling up against blocks of ice. If this should make the reader shiver, let me mention that the superheater gauge indicated 725 deg. Fah. when the engine was well away, and the "Ashcroft" exhaust pressure gauge showed 15 lb. fairly often. It looks as if either Kinne or the gauge were misbehaving—unless the front end needs a little refining.

De Kalb, 23 miles from Geneva, was reached at 12.48; average speed 55 m.p.h. We got away again at 12.54, six minutes late. The quick stopping power of these engines was very noticeable; all wheels are air-braked—steam brakes are not used in America. A mail bag was picked up at

rubbing brake, but the delay cost five minutes and the "Limited" pulled into Dixon, the next station, at 1.48, eleven minutes late. It had averaged 49 m.p.h. over the 40 miles from De Kalb, with two stops totalling 7 min.

As is often the case, some speculation had been induced by my presence in the cab; "you must have a lot of drag," suggested Kinne. "I have been on the road thirty years and I never had anyone except railroad officials riding with me before." I explained what the drag was; "Ah! I guessed it must have been something like that"; all mystery dispelled. "Drag," by the way, is American for "pull."

The more I see of the mechanical stoker the more I like it; it is efficient, easily regulated to produce any desired result, and does far better work than could possibly be achieved by a scoop with a perspiring fireman behind it. Its appearance was, of course, inevitable in America—"needs must when a 91 square feet fire-box drives," equally with the Devil. On one occasion some large lumps blocked the opening to the conveyor, and Moseley had to clear them away. The inlet seemed about 18in. square and the conveyor 9in. pitch.

My notes again refer to the riding: "Admirable—almost as good as '4793.'" If the reader does not understand this cryptic remark, let him turn up THE ENGINEER of October 13th, 1939, in which I told of a run on L.N.E.R. "No. 4793," a locomotive Rolls-Royce. "No. 4004" was very comfortable. These big wheels, the complete absence of thresh and rattle, and the perfect balance unaffected by the thrust of 25in. cylinders, gave her a motion that made up the sum of the good behaviour that one looks for in a locomotive, but does not always get. It must have been in perfect condition. The crew, and everyone concerned with this class, spoke in admiring terms of them—as well they may.

Approaching Sterling, the train ran along the

bank of Rock River, a fine stream soon to make common cause with the Mississippi. The stop was made at 2.02, 14 min. late ; the 11 miles from Dixon had taken 15 min., a 44 m.p.h. average. Poking round the engine during the halt, I found one of the big-ends too hot to bear my hand on ; they have grease lubrication. Moseley noticed my prompt recoil. " Not smoking, is she ? " " No," I assured him. " Then she's O.K." Pulling out at 2.09 we ran for several miles beside the river to a stop at another little town, Morrison, also not in my timetable. In, 2.25 ; out, 2.27. Thence down a long and in places heavy gradient, over the Mississippi River by a three-span steel bridge, past several of those ungated crossings (notice-boarded : " Look out for the cars " ; but there are a lot of jackasses in the world who do not), and we came to a stand in Clinton at 2.42 p.m. The overall average speed for the 138 miles from Chicago had been a little more than 44 m.p.h., which includes eight stops totalling 33 min., the actual running time being 154 min., making no allowance for slowing and getting away again. This, with a 1200-ton train, is very good work, though nothing at all to extend " No. 4004 "—she never even had to pick her skirts up.

A train that stops eight times in 138 miles may well be termed " Limited," but can it truthfully be called " Express " ? Not to my idea ; it seems a terminological inexactitude.

" The Limited," which had left Los Angeles two days before, was booked out of Clinton at 5.15 p.m., but it was late getting in, looking travel-stained and dusty after its 2000 miles journey from the Pacific, over mountain, plain, and desert. It was seized on by the ground crew and serviced, pulling out on the last lap of its long run at 5.35, 20 min. behind time. Kinne and Moseley were again my companions, Clinton being their " turn-around " point. Enginemen in North America never seem to do runs of more than 150 miles. The engine was " No. 4002," similar to the one I had ridden in the morning. The load was sixteen cars, approximately 1300 tons, and the weather threatening. It broke in thunder showers shortly after leaving, but no slipping occurred on the wet rails, the booster always coming into action at starting. It is cut out before 12 m.p.h. is reached, so it is not available under free running conditions or up heavy gradients —only at starting. The pressure was a little down at first, when leaving Clinton, to 260 lb., and the superheater figure was likewise, the gauge showing 675 deg., but both soon picked up when a few more revolutions were given to the stoker engine. The " Ashcroft " gauge had a third hand, fixed, to show the permitted exhaust pressure, 15 lb.; this seems a little on the high side.

Just after the Sterling stop, Kinne asked me if I wanted to see the real original Uncle Sam. Putting on the usual vacant grin one assumes when asked a question one does not understand, I said, Yes, I did. " Well, there he is, on that roof," pointing to a grey-bearded ancient standing on a shed alongside the track, vigorously swinging a brakeman's lantern, " giving us the highball." It was the sole remaining and apparently satisfying occupation of an old railwayman, to give the right of way to passing trains, and speed them on their journey. It seemed a safe and harmless amusement (provided the roof did not give way) ; evidently, he was just as happy as if he were all there.

At Dixon water was taken, several thousand gallons entering the tank in less than 2 min. thanks to large pipes and openings. Kinne told me to watch the start closely, as it had to be made up a stiff gradient, complicated by a sharp reverse curve. My notes say : " Very fine start, with only a slight momentary slip." The load, as mentioned, was 1300 tons. Nearing De Kalb, the diesel streamliner " City of Denver " flashed past, travelling at possibly 100 m.p.h., with its " Mars " headlight weaving to and fro across the track. Ours was doing the same now, as darkness was falling ; it certainly has a curious effect when you see it coming towards you, and attracts attention, which is the object of it.

There was one amusement I was deprived of on this Clinton run—there are practically no track signals to be looked for, save when nearing the terminals, as they are found in the cab itself, taking the form of lights in front of the engineer. The automatic train control, already mentioned, is the G.R.S. system, which imposes a speed restriction of 73 m.p.h., sounds a warning and applies the brakes. The receiver is placed behind the pilot (cow-catcher), the governor and amplifier being driven from an extension of the front bogie axle on the right side. There is an acknowledging contactor in the cab, and the necessary signals. As all this was described in THE ENGINEER recently, I need not-enlarge on it here. After Rochelle the warning horn sounded several times—Kinne was evidently trying to make up those 20 excess minutes—and after Geneva, the last halt, the speed remained close to 70 m.p.h., until the outskirts of Chicago were reached, and caution imposed.

It got quite chilly after dark in that open-backed cab, and the ice water jar had a rest ; in fact, I was glad to stand with my back to the fire-box to keep warm, and avoid the draughts that had been so welcome earlier in the day. And so we ran in through the light-spangled suburbs of Chicago, with the searchlight on the summit of the Wrigley Building sweeping round and giving us our point of direction, to a final stop in Madison station at 8.39 p.m., 6 min. ahead of time. The 20 min. had been more than made up, and the frequent warnings from the horn were explained. The 138 miles from Clinton had been covered in 182 min., inclusive of six stops, adding up to 14 min., and the average gross speed had been 45 m.p.h. Nothing extraordinary, but the stops and train weight should be remembered.

To conclude. This article draws a sketchy outline of a very fine locomotive, and describes some of the work it does. It is not perfect—I mean the locomotive, of course. There is no such thing as a perfect locomotive. " Perfection is finality, and finality is death." But the design is certainly as advanced as any with which my locomotive peregrinations have brought me into contact ; progressive, yet not freakish ; sound, not experimental. It embodies devices that should add to locomotive efficiency—it is high time some of them were tried out in England. A fast and powerful engine, which I should have enjoyed watching on work bringing out its potentialities more fully, as it should be easily capable of hauling 1000-ton trains at an average speed of well over 60 m.p.h. During these runs the ample boiler power was evident ; there was no need to nurse the engine to avoid cylinder starvation. The riding was excellent, as also was the balance. The track was probably not suffering unduly, or at any rate not more than it is bound to suffer when the coupled axles carry over 96 tons. This figure would be heartily damned in England, and counted a blemish, but factors in railway practice differ so widely on the two sides of the Atlantic that I am not going to be too dogmatic on this matter. In any case, they do not seem to mind broken rails nearly so much in America as we do—probably they are more used to them !

The roller bearings fitted to all axles—though these are not yet universally accepted as an improvement, enough has already been found in their favour to warrant continued trials, which alone can prove or disprove the advantages claimed for them. High pressure, siphons, arch tubes, and so on—these are almost standard practice in America, and it would be interesting to see them given a proper trial in England. The factor of adhesion, 3·93, is a little low, but with the booster to offset it at starting, when it would be chiefly felt, this probably does not have much importance. Perhaps a minor criticism—yet to me not so very minor—I was surprised to find no window wipers on this up-to-date machine, all the more now that I know a really effective clear-vision device exists, the " Kent " revolving pattern. But as this was all I noticed lacking, it speaks well for the sum of what was there, and evidently I had no excuse for damning the " E 4 " class with faint praise.

I am much indebted to Mr. Michael, the C.M.E. of the C. and N.W.R., for his courtesy in arranging the runs, and for putting so much technical information at my disposal, much of which, to my regret, has had to be left out, owing to lack of space—perhaps only for the time being. I am also grateful to the crew for the good-fellowship shown to the stranger within their gates, to the enjoyment of which a little leg-pulling only added. It seldom pays to be dignified in a locomotive cab—certainly not in an American one, at any rate. Be human !

(To be continued)

STEEL WORKS EQUIPMENT.—The Wellman Smith Owen Engineering Corporation, of Victoria Street, London, has sent us a copy of a very handsome brochure which it has recently completed. The Corporation informs us that owing to the present restrictions this volume cannot be sent out broadcast, but that it will be happy to forward copies to readers of THE ENGINEER who may be genuinely interested in steel work and associated plant. The brochure is in fact a thick album of reproduced photographs of plant for which the Corporation has been responsible, with brief explanatory text. An excellent coloured plate of an open-hearth furnace forms the frontispiece.

Sealing-In the Time Capsule

ON Monday, September 23rd, the " Time Capsule," the " letter " addressed to peoples living 5000 years hence, was sealed in at the New York World's Fair. The Time Capsule was deposited in the grounds outside the exhibition building of the Westinghouse Electric and Manufacturing Company two years ago, on September 23rd, 1938, before the Fair originally opened. The well into which it was lowered was left open. World-wide attention aroused by this plan to leave a record of our times for people living seventy lifetimes hence brought nearly 4,000,000 people to the Westinghouse exhibit to peer down the well in which the time capsule rests.

During the sealing-in ceremonies 500 lb. of a special mixture of pitch, chlorinated diphenyl and mineral oil were poured round the capsule. This compound resists electrolysis and is impervious to moisture and will provide a first line of defence against the destructive effects of time. It was developed by J. G. Ford, a Westinghouse chemist, as a seal for condenser bushings in circuit breakers. The compound remains plastic from 40 deg. Fah. below zero to 185 deg. above. It will therefore not crack open to enable the start of electrolysis by the action of acids in the earth with the metal. Its dielectric strength enables it to resist an electrical discharge up to 40,000 volts. It is one and one-fifteenth times as dense as water, so that no moisture can penetrate it to start corrosive action. It will, it is claimed, adhere tightly to the metal for many hundreds of years and through a wider variation in temperature than that to which the time capsule will be subjected. The capsule itself is made of " Cupaloy," an alloy of 99·4 per cent. copper, 0·5 per cent. chromium and 0·1 per cent. silver, which can be hardened to the temper of mild steel, but retains resistance to corrosion equal to pure copper.

Archæologists of the future will obtain a considerable insight into our present civilisation when they open the " Time Capsule." More than forty articles used every day by people of the present age are packed in it. Among them are a fountain pen and mechanical pencil, a watch, an electric lamp, a tobacco pouch with zipper, tobacco, pipe, cigarettes, cosmetics, a woman's hat, eyeglasses, toothbrush and powder, a miniature camera and film, a razor, a can opener, specimens of money, and so on. In addition, there are samples of the major metals and alloys ; textiles, including wool, cotton, silk, linen, rayon, glass fabrics, rubber fabrics, asbestos cloth ; materials such as Portland cement, asbestos, synthetic and natural rubber, synthetic plastics ; also samples of coal—which may be rare in 5000 years—seeds of staple food crops, and many other items.

Possibly the most important item packed in the time capsule is a carefully prepared microfilm " essay " on our times, taken from books, almanacs, pictures, catalogues, &c., and arranged to cover all the major activities of human life. Multi-lingual texts, a dictionary and an idiomatic lexicon will enable future historians readily to translate the texts of the microfilm. All film in the capsule is acetate, specially prepared for permanence. The microfilm essay contains more than 23,000 ordinary book pages, reproducing more than 10,000,000 words and many hundreds of pictures. A microscope is enclosed to enable " futurians " to read the text. Complete directions are given for the construction of a larger reading machine and a motion picture projection machine. For use in this machine a newsreel is enclosed, especially prepared for the people of A.D. 6939, containing nearly a score of historic, typical, or significant scenes of our day, together with a record of their sounds.

Tin Smelting in America

ACCORDING to the New York correspondent of *The Times*, the United States Government has decided to construct a tin-smelting plant in America, in order to deal with Bolivian concentrates. It is proposed to build a plant which will have a capacity of about 18,000 tons of fine tin annually for the next five years. That quantity, it is expected, will suffice to ensure an adequate supply of the metal required for defence purposes. For some years past practically the whole of the tin ores produced in Bolivia have been shipped to Great Britain or the Continent of Europe for smelting. It is recognised that the cost of producing fine tin in America will be higher than in England, and that an increase of more than 30c. per pound of metal produced must be reckoned with. For that reason the smelting in America will be looked upon as an emergency operation. An agreement has, it is announced, already been made with the Bolivian producers by the Metals Reserve Company, a subsidiary concern of the Reconstruction Finance Corporation, for obtaining the necessary concentrates, and it has the approval of the Bolivian Government. An agreement has also been made with the British Government to release to the American company upon request a quantity up to 6000 tons of ore per year, and to consider the release of still larger amounts of ore as the smelting programme develops.

Air Force Targets in Germany

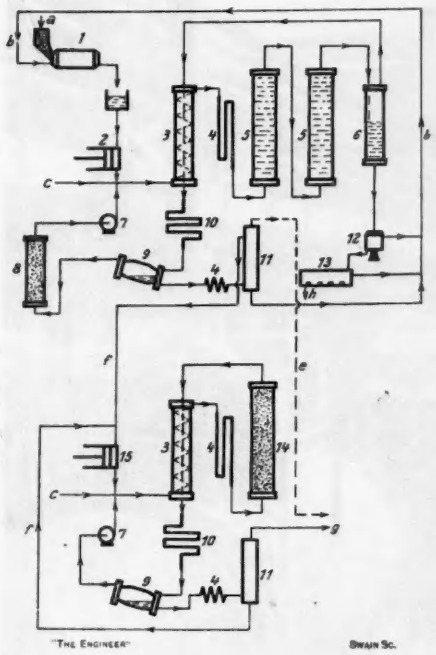
No. X

(*Continued from page 280, November 1st*)

THE LEUNA WORKS OF THE I.G. FARBENINDUSTRIE

OUTSTANDING among recent attacks made by the Bomber Command of the Royal Air Force on important industrial targets in Germany have been those which have been directed against the Leuna Works of the I.G. Farbenindustrie, at which some 400,000 metric tons of oil are produced each year. The works form one of Germany's key production centres, and as such are strongly defended by light and heavy anti-aircraft guns, which are supplemented by a balloon barrage and batteries of searchlights. The first attack was delivered on these works on Friday, August 16th, when one of the smokestacks was demolished, oil storage tanks set ablaze, and the compressor house bombed. Further attacks were made on September 29th, October 16th, and again on October 29th, and in all these attacks high explosive bombs and incendiary bombs were dropped, causing much damage to the plant by explosion and the resulting fires.

The hydrogenation works of the I.G. Farbenindustrie were begun on a large scale as early as 1924, and were founded on the work already carried out before the last war by Bergius on the liquefaction of coal, which, when exposed at high temperature and pressure, in the presence of hydrogen and a catalyst, is converted, oil being formed. Most of the later developments have been concerned with the finding of suitable active catalysts by which the reaction process has been gradually speeded up. In this connection, reference may be made to the work of Matthias Pier, C. Krauch, and C. Bosch, who made possible an early commercial application of the development work. As early as November, 1925, it was possible to use reaction chambers having a diameter of 500 mm. and by 1927 the large plant at the Leuna Works was in operation and was functioning on successful lines. Among the fuels which serve as raw materials for the hydrogenation process are lignite or brown coal, crude oil, tars, and bituminous coals. The process has been adapted to the use of all these fuels, either separately or in combination, and by a modification of the working temperatures and pressures it is possible to produce by changes in the reaction process the desired amounts of middle and light oils and fuel gases. Among the proprietary brands of fuels manufactured at the Leuna plant and the allied works, which in Germany are marketed by the Deutsche Gasolin Aktiengesellschaft, of Charlottenburg, Berlin, are Leunabenzin, Leuna-mixture, and Methanol for admixture with motor transport fuels, and the industrial and heating gases Leuna-propane and Leuna-butane, and their mixtures, which may be supplied either in compressed or liquid form.



Plant Units

1.—Coal Mill
2.—Slurry Pump
3.—Heat Exchanger
4.—Heater
5.—Coal Retort
6.—Separator
7.—Gas-Circulating Pump
8.—Gas Purification
9.—Stripper
10.—Condenser
11.—Distillation Plant
12.—Centrifuge
13.—Low-Temperature Retort
14.—Light-Oil Retort
15.—Oil-Injection Pump

Flow of Materials

a.—Coal *b*.—Oil for admixture with coal *c*.—Fresh Hydrogen
e.—Light Coal Oil *f*.—Middle Oil *g*.—Finished Benzene
h.—Ash

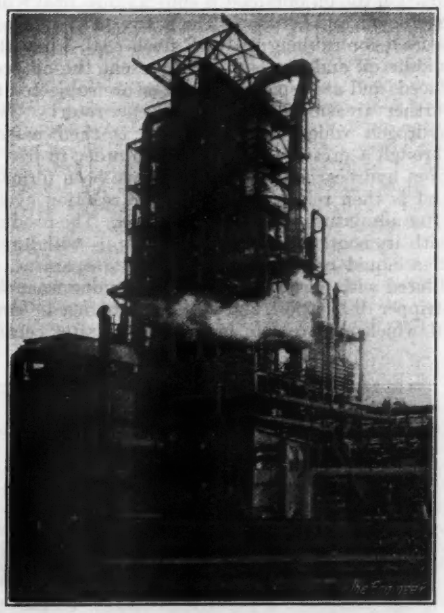
DIAGRAM OF HIGH-PRESSURE HYDROGENATION PLANT

REACTION VESSEL

The large size of the plant will be seen from the engravings, mostly taken from works photographs, which we reproduce herewith. They show the large scale of design which has been adopted, the many lines of interconnecting pipes, high-pressure valves

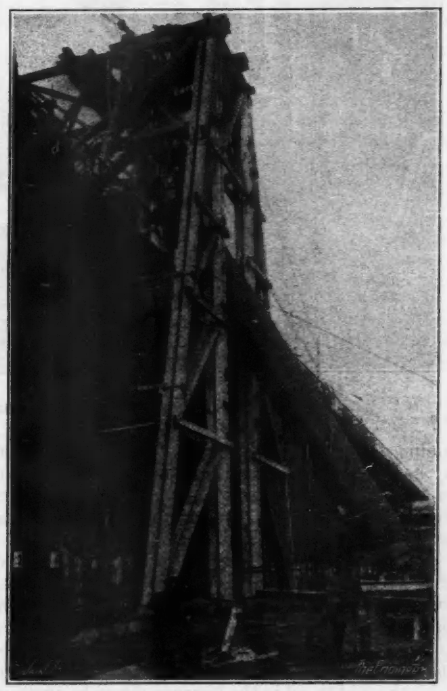
GAS-FIRED PREHEATER

for control, and the high cranes which are employed for the construction of the plant and its maintenance. The general principle employed is shown by the diagram herewith, which indicates the plant units and the flow of the materials used in the process. The characteristic feature of the high-pressure hydrogenation process used at Leuna, whether employing brown coal, bituminous coal or tars, is as follows :—The coal is first broken up and then mixed with heavy oil and finely ground in a drop stamp mill. Part of the catalyst, which has been pasted up well with oil, is here added to the coal slurry, and the rest is added later on. The coal slurry or paste, which contains from 50 to 60 per cent. of solid matter, is drawn through high-pressure slurry pumps and pressed together with hydrogen at a pressure of about 300 atmospheres, the mixture passing through a heater system consisting of a heat exchanger and a gas-heated preheater.



CONTINUOUS DISTILLATION PLANT

One of the reaction vessels suspended from the crane in front of the reaction chamber installation is illustrated and another engraving shows one of the gas-heated preheaters, which is employed to bring the mixture up to the temperature for the reaction process. The coal slurry and the hydrogen are brought up to a temperature of about 410 deg. Cent. before being introduced into the reaction vessels. Owing to the heat of reaction the temperature rises to about 460 deg. Cent. in the vessel, and at that temperature the coal molecules are broken down under the influence of the admixed catalyst and of the highly compressed hydrogen, according to the choice of the throughput, to form middle oil and benzene, together with small quantities of gaseous hydrocarbons. The heat, which is further developed in the course of the reaction, is carried off so as to prevent the temperature from rising above 460 deg. Cent., by introducing into the vessel at suitable points quantities of cold oil, coal



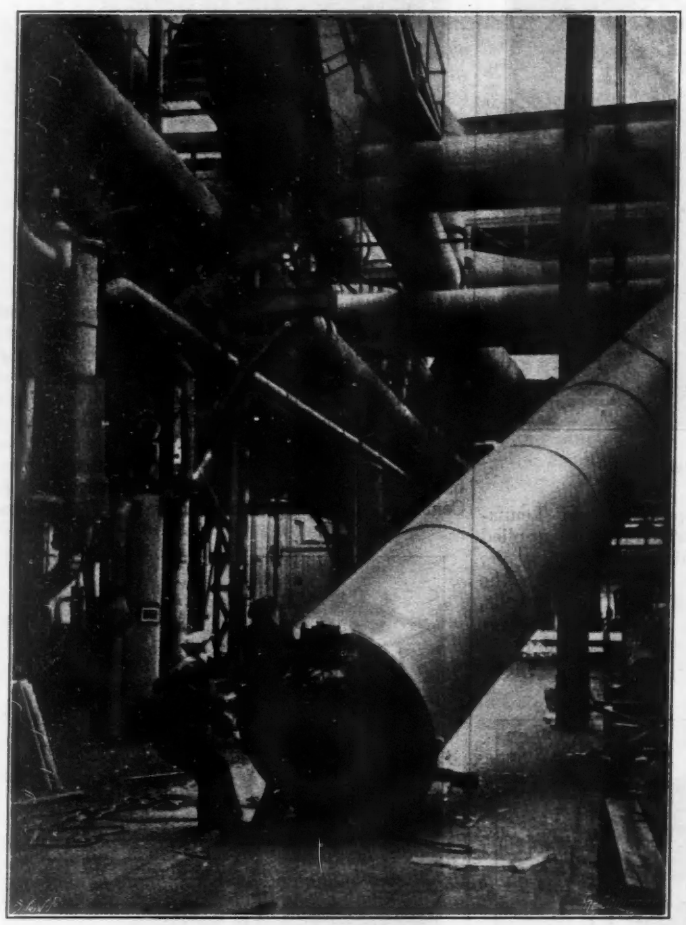
GAS WASHING PLANT UNDER CONSTRUCTION

slurry, or gas. The products of the reaction after completion reach a hot separator, in which practically the same temperature prevails as in the reaction retorts. The heavy oils, which have remained liquid and contain ash and residual coal, are there separated from the gases and the light oils. The light oils leave the separator in the form of vapour and are cooled in the heat exchanger and the condenser, and are then separated in a stripper from the hydrogen and gaseous hydrocarbons which are present. In the stripper distillation the oil obtained is split up into heavy oil, middle oil, and benzene. The heavy oil so obtained is used for rubbing up with fresh coal, while the middle oil and the benzene represent the oil produced, and are separately used or are subjected to further treatment in the benzene retort. The hydrogen which is stripped off is then passed through a pressure oil scrubber in order to free it from hydrocarbons which may have been formed, and is then reintroduced into the reaction cycle, after admixture with fresh hydrogen. The residue, with its contents of solid materials, is withdrawn in a liquid condition from the hot separator, is diluted with part of the heavy oil coming from the stripper distillation, and is then centrifuged. Any oil which may remain in the residue after centrifuging is separated in a low-temperature retort by heating with the addition of steam. Heavy oil re-gained by low-temperature carbonisation, centrifuging, and stripper distillation, is used for the scrubbing up of fresh coal.

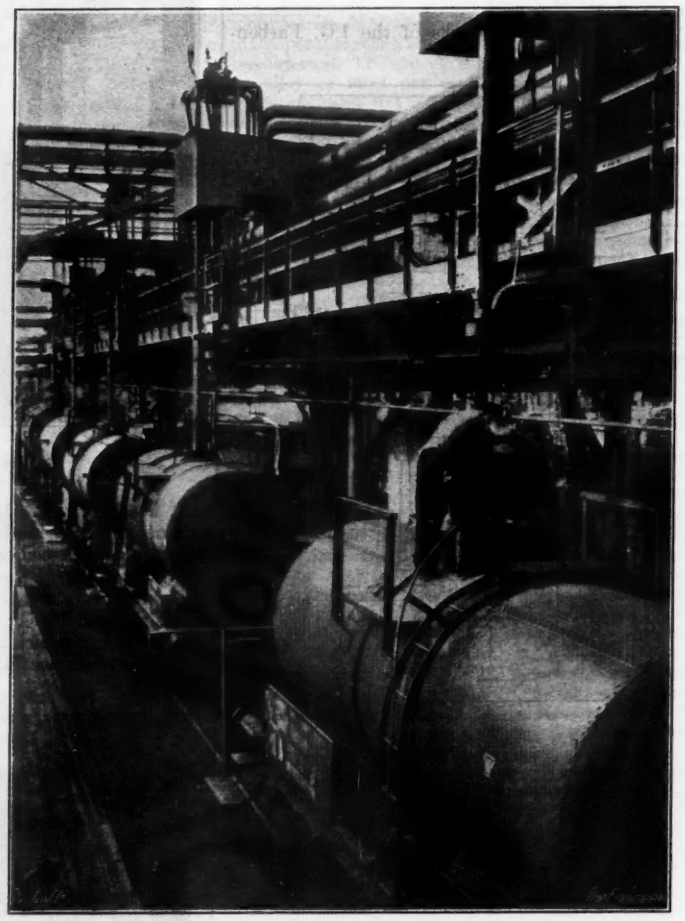
The middle oil produced by the hydrogenation of coal in the first stage of the process is conducted over a stationary catalyst in the second stage of the process in the benzene retort. The benzene which is contained in the coal retort can be refined by itself in the usual way or it can be purified together with the middle oil in the benzene retort by pressure hydrogenation. The middle oil is introduced into the light oil retort, which is filled with lumps of the catalyst. The oil is injected by a high-pressure pump and is circulated through a heat exchanger and a preheater. The conversion to benzene takes place at a pressure of about 300 atmospheres and a temperature of about 400 deg. to 520 deg. Cent. The product which is thus obtained is cooled in the heat exchanger and the condenser, and the hydrogen is separated in a stripper and is returned to the cycle. The resulting product is split up by distillation into benzene and middle oil, which is again introduced into the cycle and converted into benzene. The benzene is scrubbed with lye and is then ready for sale as coal petrol or motor spirit.

Should brown coal or lignite be utilised instead of bituminous coal, the process employed is generally similar to the one we have described, but a coal drier is placed in front of the coal mill, which is preferably a ball or roller mill, with the object of reducing the water content of the lignite to a suitable degree. By adjusting the working temperatures and pressures and using modified catalysts, benzenes suitable for use as motor spirit are produced. One of the most simple of raw materials is low-temperature tar, which enables the coal plant and the plant for the treatment of the coal residuals to be dispensed with. When low-temperature tars are used, they are first freed from solid admixtures by centrifuging and are then split up by further distillation into a light and a heavy component. The heavy component is introduced into the first stage retorts.

The photographs reproduced with this article show clearly the principal sections of the plant, but do not illustrate the high-pressure hydrogen compressing plant, the high-pressure fuel injection pumps, and high-pressure steam boilers. Photographs of the continuous distillation plant, and of one of the gas-washing plants in course of erection are reproduced. The interconnecting pipes are run on overhead gantries, and one of the views we reproduce shows a typical group of pipe line connections. In our last illustration we show the loading of tank wagons with Leuna motor spirit. In conclusion, it may be stated that similar plants have been erected in Europe and America, in collaboration with the I.G. Farbenindustrie, among which may be mentioned those in Italy which have been built at Bari and Leghorn.



TYPICAL PIPE CONNECTIONS



LOADING TANK WAGONS WITH LEUNA MOTOR SPIRIT

Technical Education from the Employer's Standpoint*

By W. H. CARRIER†

THERE are at least five different features in our present-day technical education which are justly subject to criticism. These, of course, do not apply equally to all institutions, but can be accepted as fair criticism of the average institution. They are as follows :—(1) Trend toward specialisation in undergraduate courses ; (2) lack of proper standards of selection of students to be admitted to engineering courses ; (3) failure to develop in the student the habit of thorough understanding of subject-matter and processes ; (4) insufficient emphasis placed on development of student personality ; (5) examinations and student grading which are not the true test of student ability desired by the employer.

It would seem that there is one underlying error common, at least in practice if not in theory, in most of our institutions to which these various faults may be traced. This is the failure to appreciate that the chief objective of a technical education should be to train the student in logical thinking and develop his creative imagination ; that it should be aimed primarily toward the acquisition of power rather than toward the amassing of factual knowledge. Many educators will not admit that this is a sound accusation, but while many agree with this statement in theory they fail to carry it out effectively in practice.

* * * * * *

Thoroughness, which includes and emphasises understanding, should be the first objective of engineering training. According to the experience of employers, if thoroughness is acquired other results of education are relatively unimportant. Factual and specialised knowledge is attained rapidly with opportunity in the graduate's chosen field.

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Probably more than 90 per cent. of the students do not follow the field in which they have specialised when at college. Circumstances and opportunity for employment play the most important parts in the ultimate selection. In other words, 90 per cent. of the time and effort spent in specialisation, except as it may be useful as training in the application of fundamentals and thoroughness, is entirely wasted.

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That technical employers even in highly specialised fields are solidly opposed to undergraduate specialisation is well borne out by the investigation made by Dean Hollister, of Cornell University. He recently visited four of the leading aeronautical industrialists to discuss the desirability of introducing at Cornell a curriculum in aeronautics similar to that which has been established in a few technical schools. Somewhat to his surprise, all these industrialists were definitely opposed to the idea of attempting to include such a curriculum in a four-year course. They gave reasons similar to those I have advanced and further backed their opinions by citations from their experiences with engineering graduates. They all preferred a broad engineering education, based on a thorough training in fundamentals during the first four years ; if highly specialised training were to be given it should be confined to a post-graduate course in the fifth year.

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Training in thinking is far more important than the

* Excerpts from a contribution on Education and Training for the Industries. The American Society of Mechanical Engineers.

† Chairman of the Board, Carrier Corporation, Syracuse, N. Y.

mere acquisition of factual knowledge. Employers do not want human slide rules or walking encyclopædias of engineering knowledge. They want graduates trained in logical thinking, in habits of thoroughness, and in the scientific method of approach.

* * * * * *

In engineering education the aim should be to have no fact or theory accepted until it is first thoroughly understood. Memorising without thorough understanding does not develop the habit of mind that is so necessary in later life to the successful engineer. On the contrary, it leads to a habit of taking things for granted, and often to a feeling of mental helplessness and inferiority fatal to mental progress in later life.

The engineer who advances the boundaries of his profession must have curiosity and an inquiring mind. These natural mental attributes should not be deadened or stultified in the process of technical education, but should be stimulated and developed. The student should be encouraged and required to do everything for himself that he can accomplish through his own mental processes without recourse to text or oral instruction. Teaching should be through guidance rather than through enforced assistance. The inductive method should precede the classical and commonly overdone deductive method.

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Very much more time should be allotted to the mastery of the elements of a subject, largely by the inductive method, and very much less time spent on the presentation of the more extensive details of the subject. Thoroughness should be aimed at rather than completeness.

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Instructors must be taught how to teach and be imbued with the proper ideals of education. To-day we have many teachers but few educators.

* * * * * *

There is a tendency in our schools to over-emphasise the technical side of education at the expense of the human aspect. The engineer's success depends fully as much on his ability to deal successfully with human problems as it does upon his ability to deal with mechanical problems. Indeed, if a man possesses the latter ability without the former, he may be a failure, even as an engineer, while with the former, even without the latter, he will at least succeed as a man. It has been truly stated that few engineers lose their jobs because of lack of technical ability. Jobs are lost largely because of failure in human relations.

Many believe that the important subject of human relations can be taught only through environment and example. I must confess that I, too, was once of this opinion. However, this essential element of education should not be left wholly to chance.

* * * * * *

While it must be admitted that examinations employing a system of marking are useful and necessary, far greater stress should be put upon a thorough understanding of principles and their application, rather than upon factual knowledge or facility in engineering calculations. Where a passing mark of 60 per cent. is now required indiscriminately, there should be two examinations: the first, to test the thorough understanding of essential principles, should require a passing grade of 80 per cent.; and the second, to test factual knowledge and facility in engineering calculations, may require only 60 per cent. This is based on the theory that a man who does not understand what he is doing will never make an engineer.

South African Engineering Notes

(By our South African Correspondent)

State Industrial Corporation

THE Government is at present engaged in selecting the board of directors of the Industrial Development Corporation for which statutory provision was made during the last session of Parliament, and the Minister of Commerce and Industries hopes to make an announcement within the next few weeks. The Corporation's efforts will be distinct from the war industrial effort as such. Whatever industries are to be established under the Corporation will have to be economically sound and able to stand on their own feet. It may be assumed therefore that it is the Government's intention to develop South Africa's ordinary industrial potentialities side by side with its present extraordinary war effort. Though it is anticipated that many of the industrial enterprises which are now manufacturing war equipment will be able to stand on their own feet as peace-time industries when the war ends, the Industrial Development Corporation will strike out in creating other national industries. The capital of the Corporation will be £5,000,000, divided into 500,000 £1 A shares and 4,500,000 £1 B shares. The Government, no matter how the Corporation expands, will always retain control, as it is laid down in the Act that the A shares held by the Government shall entitle the Governor-General to a number of votes which shall exceed by one the total number of votes which all other shareholders of the Corporation may be entitled to in respect of shares held by them.

Union's Industrial Expansion

The preliminary results of the Industrial Census in 1938 just published show an increase in the gross output of all undertakings, compared with the previous year, by £12,281,000, or 7 per cent., to £187,486,000, of which £165,860,000 is represented by private establishments. The wage bill reached a total of £44,770,000, which is more than double the figure of 1932–33. The output of private establishments increased by £10,258,137. Metal and engineering trades augmented their output by £3,239,000 to £31,223,000; the food and drink industries by £3,110,000 to £44,255,000; chemical industries by £1,223,000 to £11,558,000; building and contracting by £1,166,000 to £16,360,000; electric industries by £893,000 to £8,905,000; and other trades by smaller amounts.

The census covered 10,224 industrial establishments with a fixed capital of £106,577,000 and employing 348,520 persons, including 143,760 Europeans. Mining and quarrying was not included in the census. The number of European employees increased by 2·6 per cent. and non-Europeans by 6·3 per cent. Of the total wage bill, European employees received 72 per cent. and non-Europeans 28 per cent. South African materials used increased from £42,683,480 to £46,323,490, and all materials used from £80,705,121 to £84,699,700, indicating that imported materials now take second place. The gross output of the industry amounted to £165,860,403.

Cement-Bound Roads

The town of Parys in the Orange Free State can claim to have been the first municipality of the Union of South Africa to have successfully put down cement-bound streets. Winburg, Colesberg, Nelspruit, and possibly Senekal are following suit. The Town Clerk mooted the scheme after investigating a Continental road scheme. As a result, the municipality is now assured of streets which with ordinary wear should survive for decades—half a century is mentioned. The method used is termed "sandwich" construction. The road is made up of 4in. of 2in. drystone on a prepared bed, on top of which a cement mulch 1½in. thick is spread, covered with a layer of 2in. dry stone. This pack is rolled continuously till the cement is worked through the crushed stone, after which bass brooms are used to remove any excess cement. The road is then covered with sisalkraft till it is ready for use. The whole process usually takes ten to fourteen days.

The Town Clerk states that his estimate shows that the cost of laying a cement road, 20ft. wide, is £2200 a mile, and maintenance is reckoned at £8 a mile per year. He estimates that a good asphalt road would cost £2500 a mile and up to £80 a mile to maintain. American cement highways, he says, are laid by a road paver, which costs about £9000. The paver is capable of laying a mile of 20ft. wide road per day. The rateable value of Parys is £500,000, and the rates are 3¾d. in the £. The town is a notable holiday resort, visited by about 10,000 people a year.

Diamond Cutting and Base Metals

Developments in the diamond cutting and the base metal industries are foreshadowed by the Minister of Mines. The Minister said the diamond-cutting industry and the development of the base metal industry in the Union were being greatly stimulated by the war. After the collapse of Holland, the centre of the diamond-cutting industry, a great many master diamond cutters in Europe were thrown out of employment. These cutters were being invited to take advantage of the favourable conditions existing in South Africa, and to establish themselves there. The special preference of 10 per cent. on the export tax on cut diamonds was proving particularly advantageous to these highly skilled men. The Government was favourably disposed to the establishment of their enterprise in South Africa. The existing diamond-cutting industry in the Union, such as it was, was flourishing.

The production of base metals has increased considerably, and the prospects for the future are exceptionally good. At present minerals are being worked at a margin of profit which has not been possible in the past. Minerals whose existence was unknown before the war are being developed. The work of the Geological Survey Department, backed and helped on by the Union's research laboratories, has given a much more favourable outlook to all South Africa's base metal mining enterprises.

War-time Shipping Boom

The ports of the Union of South Africa, and particularly Table Bay, upon which Cape Town stands, are handling more shipping now than ever in their history. This war-time boom has brought abounding prosperity to Cape Town, "the gateway to South Africa," and now, with the Mediterranean route practically closed, more than ever deserving of the title of "Tavern of the Seas," given it by the mariners a couple of centuries and more ago, because at Cape Town, as a "half-way house" between Europe and India, they revictualled their ships on outward and homeward voyages. In past years it was the exception for ships to ask at Table Bay for anything beyond vegetables, fruit, and small quantities of meat, and, for steamers, coal. Now, with all Europe conserving its supplies, not only of foodstuffs, but other necessaries, ships of all nations are being ordered to get as much as they can of their requirements abroad, and when homeward bound to buy all the extra supplies they can carry, and so contribute to the home reserves. Cape Town, as the focal point of many trade routes, is reaping a rich harvest from all these customers, and its crowded docks are also a sufficient reply to the Nazi boast that the British Navy no longer rules the seas.

Extraordinary sums are being spent in Cape Town daily by the ships that stream in for supplies of fresh vegetables, fruit, meat, and dry stores. One ship a few days ago went away with £2000 worth of fresh vegetables alone. Three ships sailing in company the same week between them bought £19,000 worth of food and stores of all kinds during their few hours' stay, and vessels handled by one Cape Town agency alone spent £30,000 in stores in one week, quite apart from the thousands of pounds spent in dock charges, and on fuel and other services. Ships are buying huge quantities of fruit and meat, butter, eggs, cheese, flour, milk, and biscuits. Local wines, beer, and mineral waters are being shipped for canteens in quantities never before known. Besides the canteens are being stocked with clothing, stationery, and everyday necessities, even to fountain pens. Paint, rope, and wire for ships' own use are also in demand.

Southern Rhodesia's Mineral Output

The mineral output of Southern Rhodesia in July was £768,199 for all minerals and £586,450 for gold (69·815 fine ounces). The increase in the gold production over the previous month is 608 oz., and the value of the gold won is greater than in July, 1939, when, however, the price of gold was £1 an ounce less than to-day. The base mineral production for July (£180,236) also shows an increase over the figures for the preceding month, and for July of last year. These results have been achieved despite the dearth of native labour and increased working costs, and are largely due to the operations of the small-worker section of the gold-mining industry, which aims at contributing the maximum of its resources to the national war effort. Another record year of mineral production is now clearly in sight.

Mineral Resources of the Union

A third edition of "The Mineral Resources of the Union of South Africa" has just been issued by the Department of Mines. In 544 pages the volume gives a comprehensive review of South Africa's mineral deposits, output, and industrial possibilities. At the end of 1938 the aggregate mineral output of the Union had reached £2,159,214,469, of which gold accounted for £1,657,660,534; diamonds, £327,771,889; coal, £115,820,785; and copper, £30,322,785. All the other minerals contributed less than £10,000,000 each to the total.

Growth of S.A. Railways

In the thirty years since Union the goods traffic carried by the railways has increased by 418 per cent. and coal traffic by 95 per cent., Mr. C. M. Hoffe, Assistant General Manager of the South African Railways, stated recently. In that period the State has invested interest-bearing capital amounting to £165,000,000 in railways, and the Administration has paid the Government about £144,000,000 in interest charges. Revenue has risen during the past ten years from £30,000,000 to £36,000,000, and train and engine miles from 64,000,000 to 79,000,000. These figures reflect big expansion in several spheres of the country's commercial and industrial activity. In 1934 the route mileage of the road motor service of the railways had risen to 10,500. To-day it stands at 16,900, or nearly 3000 more than the route mileage of the railways. Motor vehicle miles have risen from 5,245,000 to 10,750,000. Passengers on the road service in 1934–35 totalled 2,150,000, and in 1940 6,350,000. Goods on this branch of the railways has risen from 400,000 tons in 1934 to 860,000 tons in 1940, while cream carried from farms on the routes has increased from 1,000,000 gallons to 2,270,000 gallons. In the railway catering department the value of edible and portable commodities purchased last year was £300,000, and 87 per cent. of this was spent on South African products. In one day 241 dozen eggs were used and 3700 bottles of minerals and light cordials consumed.

THE ROCKIES.—The Canadian National Railway has been running cars during the past summer on the whole of the new 186-mile Columbia Icefield Highway between Jasper, Alta., and Banff, a highway which links the premier mountain resorts of the Canadian National and Canadian Pacific. Running through the midst of the most spectacular portion of the famed Canadian Rockies in a north-south direction rather than across them, the new route permits tourists for the first time in history to see the mountain region along its backbone by motor vehicle and witness the unique character of low-hanging masses of glacial ice which are the birthplace of rivers flowing to the Pacific, the Arctic, and Hudson Bay.

The Engineer

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MACHINE TOOLS WEEK

AT a Press Conference, held in London last Monday, Mr. Harold MacMillan, Parliamentary Secretary to the Ministry of Supply and Chairman of the Industrial Capacity Committee, and Mr. P. H. Mills, Controller of Machine Tools, inaugurated a "Machine Tools Week," The machine tool census in engineering firms only, originally held about three months ago, is being repeated during the week, and an appeal, similar to that made some weeks ago by Mr. Morrison, then Minister of Supply, is again being made mainly to non-engineering firms to turn over to the Ministry for the use of the Services every machine tool not already fully employed. Mr. Mills, introducing the matter, said that the machine tool industry of this country had responded nobly to the calls that had been made on it. But it could not do everything. It was of great importance to the Ministry to be able at any time to lay its hands on a particular class of machine tool and send it at once to the right place. The licensed merchant could also play his part in that work and was being encouraged to do so. Our eventual supremacy over the enemy depended on a steady supply of machine tools and the full utilisation of those we had. The appeal and the census between them are intended to intensify effort in both these directions.

It is now clear that the earlier census of machine tools undertaken by the Ministry has proved a success. For, though as yet no definite decision has been taken, it seems likely that the census will be repeated at more or less regular intervals hereafter. The census, it may be recalled, does not merely reveal what tools are in existence and where they are placed. If it had been restricted merely to that purpose the Ministry, which is no doubt aware of the destination of all new tools manufactured in or imported into this country, would have no need to repeat it. It has a purpose more directly concerned with production, for producers are required to give figures of the utilisation of each tool during the week of the census. At present apparently the position is regarded as satisfactory if a double-shift system is being worked, for the minimum hours of work expected of any ordinary tool are ninety per week. It is the object of the Area Boards of the Ministry to provide anything, whether it be materials, skilled labour or some different class of work, which will ensure the use of the tool for that minimum period; or if the cause of failure to do so be the result of an unbalanced plant, to co-ordinate the work of a group of shops or factories so as to produce a better balanced unit. The reason for the repetition of the census now becomes more plain. Under the stress of war considerable changes can be wrought in the use of machine tools within very short periods. Many firms formerly producing goods for a peace-time market have changed over to the production of war supplies. A machine shop properly balanced for its peace-time production may become far from properly balanced when turned over to the making of other products. Moreover, the Ministry and its Area Boards cannot be expected to keep track of changes and improvements made by individual firms themselves without stimulus from the central body. The new census, it is hoped, will reveal the effect of such changes and also, perhaps, give some indication of the interruption to output caused by air raids. But considerably more than that is hoped from it. Since the last census the Ministry and the Area Boards have taken action to ease bottlenecks and generally to maintain machine tools in operation. The new census is likely to show not merely the total result of these actions, but also which methods are best adapted rapidly to bring every possible tool into maximum production. The census can therefore be regarded not only as a source of information, but also as a check upon the efficiency with which the Ministry and the Area Boards are carrying out their duties. As for the appeal that is accompanying the census, it is known to all engineers that a very great number of machine tools, and especially those general-purpose tools such as lathes, milling machines, boring machines, and grinding machines, which are particularly needed, are installed in non-engineering works for the maintenance of plant and similar purposes. Such machines receive relatively little use, and it is the object of the appeal to bring them into use for war productive purposes. Though necessary in certain cases, it is not, we understand, the intention of the Ministry to take possession of such machines and install them elsewhere, but rather that use shall be made of them for work within their capacity in their present situations.

Emphasis was laid at the Conference, it will be seen, on the importance of the adequate production and use of machine tools in the war effort. In that connection it is well to remember that the United States are now becoming increasingly concerned to re-arm. Unless the machine tool industry in that country is expanded and organised in the near future to meet the effort it would be unwise in us to depend too greatly on receiving a continuous and increasing supply of machines from across the Atlantic. The holding of another census in this country and the threat of others to follow at relatively frequent intervals will not prove welcome to engineering firms here, even if the contention of the Ministry that additional censuses will prove less irksome than the first is true. But if by that action the Ministry is going to gain information of real value and the means for effecting a yet greater and more efficient use of the productive capacity of this country, the firms concerned will loyally co-operate. "This war," said Mr. Mills at the Conference, "is a war of machines. To wage it to the utmost of our power we must have our main forces and our reserves. We must be prepared, and in a position not only to expand our facilities, but to make good damage and wear." The Ministry is attempting to see that every machine is working to the fullest possible extent, whilst the machine tool industry itself expands to meet its requirements.

Technical Education and the Employer

TECHNICAL education is a subject almost unique amongst those which are perennially discussed in that there is scarcely a single living engineer who does not hold relatively strong views upon it. If a thousand engineers were gathered together for a debate upon education a thousand different opinions would be expressed. Some, no doubt, would exclaim against the undue importance accorded to mathematics in the colleges. How many engineers, they would ask, are required in later life—or, for that matter, would dare to trust themselves in later life—to make use of the Higher Calculus over and beyond the simpler differentials and integrals? Might not time unprofitably spent attempting to drum this subject into the heads of students temperamentally unfitted to retain it be better devoted to other subjects? Others would ask what was the use of practical work with hammer and chisel and file, and with saw and square when the total time spent upon it in a whole year was equivalent only to a week or two in an engineering shop, work which could obviously be better left to be undertaken, as it was bound to be, in the period of apprenticeship? It would, too, be suggested that since the task of the mechanical engineer was to design mechanisms, then the fundamental types of mechanism as described in such works as Reuleaux's "Kinematics of Machinery" should surely form part of the curriculum. Further criticism would be made of post-graduate specialist courses, and of other post-graduate work often unwarrantably dignified by the title research; and of many other facets of technical education, not forgetting the lecture system itself, whereby in the larger colleges as many as one hundred students are expected to absorb knowledge from a distant lecturer.

There is much point in all such criticism. For it is now generally admitted that not all is as it should be with technical education to-day. But the observation may be hazarded that the faults which are found in it cannot be corrected by changes of detail. The colleges are subjects for criticism because the attitude of engineers towards technical education is changing. Once upon a time the budding mechanical engineer, for example, had little to bother with save steam engines and mechanics. But to-day the field to be covered by his education has immensely broadened. It has therefore become necessary to consider what modern education can hope to do. In the past it specialised on steam; there was little else on which to specialise. But now, when the student himself has very little idea in which of the many devious branches of engineering the future will find him, specialisation is seldom practicable. In a discussion of this kind considerable weight must be allowed to the opinions of employers, for it is for them to say what they hope to find in the young men that join their firms. On another page of this issue, therefore, we reprint some extracts from a communication by Mr. W. H. Carrier, chairman of the board of Carrier Corporation, of Syracuse, N.Y., to a Committee held in America on "Education and Training for the Industries." Mr. Carrier, like many of his countrymen, has the knack of expressing in few words opinions now held by the majority of employers. "Thoroughness, which includes and emphasises understanding, should be the first objective of engineering training. . . . Training in thinking is far more important than the mere acquisition of factual knowledge. . . . The engineer who advances the boundaries of his profession must have curiosity and an inquiring mind." Broadly, Mr. Carrier's requirements might be expressed as the three qualities—Thoroughness, Knowledge of Fundamentals, and Character.

With regard to the first two of these qualities it can be said that if the knowledge of fundamentals is there and the student has been taught how to use his mind with thoroughness, there can be no

doubt of his ability to specialise in later life when the choice of field has been made. But engineers and professors are still left to argue as to what the fundamentals are to consist of, a matter about which there is, and probably always will be, considerable dispute. But perhaps the quality of outstanding importance that Mr. Carrier mentions, and one that all engineers will agree upon, is Character. "It has been truly stated," says Mr. Carrier, "that few engineers lose their jobs because of lack of technical ability. Jobs are lost largely because of a failure in human relations." He refers to one of the facets of character, its human side, and to a point that our educators frequently miss. In our technical colleges the weight of demonstrable fact and scientific law bears heavily on the student's natural individual desire to deviate and explore until it becomes difficult not only to break away on to a novel line of thought technically, but equally difficult even to attempt to understand an outside unscientific world ruled by wayward emotion rather than settled laws. Amongst themselves—that is, amongst people whose processes of thought are similar—none are more social than engineers. But they tend to stand apart as a separated group. Some of this narrowness, as we suggested in a recent leading article, is a direct result of the absorbing nature of the work of an engineer. But the colleges, too, we believe, must take their share of the blame for its existence owing to the emphasis they place on technicalities. We cannot go all the way with Mr. Carrier, who appears to believe that the subject of human relations can actually be taught. But it is possible that were technical education more directed towards the encouragement of individuality and the development of character, rather than to the production of well-endowed technical men, engineers would have a better chance to play that important part in the rebuilding of the social structure of the world that is their due.

Electricity on the Farm

A REPORT on the Application of Electricity to Agriculture and Horticulture, written by Mr. C. A. Cameron Brown, has just been issued by B.E.A.I.R.A. It comprises a critical study of the applications of electricity to farms and market gardens and opens with a general essay, part of which is reprinted on another page of this issue. In the course of this essay Mr. Cameron Brown makes the good point that electricity supply companies and authorities should cease to centre their minds on the advantages that would accrue to them from an increase of consumption by farmers and horticulturists and attack the problem from the other direction—that is to say, they should "concentrate on developing electricity as a beneficial tool in the hands of the farmer." That is a sound and virtuous policy, of which the electricity supply industry might take note in other connections. Those who have listened to the recurrent and prolonged discussion of the ways and means of augmenting the load factor must acknowledge that the first interest of undertakers and suppliers is what they themselves can get out of it. No doubt they seek to convince consumers that they will be the beneficiaries, but at the backs of their minds it is their own advantage that they are considering. In that respect they do not differ from other salesmen, and it may be suggested that as "public utilities" they ought to do so. In any case it seems not improbable that a smack of altruism would be profitable in this instance. Take the matter out of the hands of salesmen and hand it over to technologists with farming experience. Let them study the problems and needs of the farmer and try to satisfy them. If they can do so, well and good; the demand for electricity will follow. If they cannot do so, they should not at once accuse the farming industry of unbreakable conservatism, but re-examine their solutions and discover the reason why their proposals are still unattractive. It may, we think, be said of British farmers that, taken by and large, they are alive to their own interests, and if they are once satisfied that electricity on the farm pays they will not hesitate to adopt it and will press for that extension of supply which the power-houses desire.

Literature

Historic Melingriffith: An Account of Pentyrch Ironworks and Melingriffith Tin-plate Works. By EDGAR L. CHAPPELL. Cardiff: Priory Press, Ltd. 1940. 5s.

THE manufacture of tin-plates in this country was established at Pontypool in the first quarter of the eighteenth century. By the year 1800 works had been set up in quite a number of places in England and Wales—in the Midlands, in Somerset, Gloucester, Monmouthshire, and in South Wales. One of the South Wales works was at Melingriffith, on the River Taff, a few miles above Cardiff, and of all the early works this alone survives as a tin-plate works. Melingriffith is still in operation, and Mr. Edgar L. Chappell has just published under the title "Historic Melingriffith" an account of the rise and progress of this well-known establishment, in which use is made of unpublished documents. It is known that a forge was in existence before 1750, but the date at which a rolling mill was installed and tinning was started remains obscure. Mr. Chappell, however, furnishes clear evidence that the manufacture of tin-plates was in full swing in 1774–75, when a second mill was in course of erection. The owners at that time were Bristol men—Reynolds, Getley and Co.—and the author suggests that Reynolds was Richard Reynolds, the well-known ironmaster of Coalbrookdale and Ketley. A few years later the works passed into the hands of Harford, Partridge and Co., and then early in the nineteenth century Richard Blakemore was in control. By that time Melingriffith was said to be the largest tin-plate works in the world; but, of course, the scale of operations was vastly different from what it is to-day. Then the annual make of 13,000 boxes was mentioned with pride; now the weekly capacity of the works is about the same figure.

In addition to Melingriffith, Mr. Chappell deals with Pentyrch Ironworks. Here, alongside the Taff, a blast-furnace was set up in 1740, or within a year or two of that date. An earlier furnace in the same locality, probably on a small stream running into the Taff, had been destroyed long before this. It was at work, using hematite ore, from the nearby Garth mountain, making iron for a steel forge at Robertsbridge, in Sussex, and, later, casting iron guns.

The book includes a short account of the process of manufacture of tin-plates and a chapter on "Early Welfare Schemes."

SHORT NOTICES

The Microscope. By R. M. ALLEN. London: Chapman and Hall. 1940. Price 15s.—Not a few good text-books have been written for propaganda purposes by the members of manufacturing firms. Internal evidence leads us to believe that this is an addition to their number. Mr. Allen, if we are not mistaken, is connected with a very well-known American firm of scientific instrument makers. Nevertheless, and although he takes little or no interest in other people's products, he has kept his book on general lines. It is not a deep book; not a book for the expert. But for the beginner who has just acquired a microscope or is thinking of buying one, or for the man who has got a bit further on and desires to enlarge his work in microscopy, it is excellent. It opens with a very lucid chapter on optical principles, passes on to chapters on microscopes for various purposes and their accessories, and ends up—more than half the volume—with instructions how to use the instrument for a variety of purposes, with particular attention to the technique of mounting, staining, polishing, and so on. Whilst, as we have said, Mr. Allen appears to be interested almost entirely in the products of one American firm, he pays, in his Preface, a handsome compliment to British makers, when he says: "It is to be regretted that English manufacturers, in particular, appear to make no effort to introduce their instruments in the United States, for some of their designs are very appealing to discriminating microscopists."

Household Physics. By Walter G. Whitman. Third edition. London: Chapman and Hall, Ltd. 1939.—This is an American book. It deals summarily with all the things about a house which can be covered by a liberal interpretation of the word physics. There are chapters on heating the house, on refrigerators, on cookers, on electrical appliances, on motor-cars, on the weather, on water supply, on optical apparatus, and so on and so forth. In each chapter the physics of the apparatus described are outlined as briefly as possible and in a manner which should be quite comprehensible to the ordinary householder. There are, moreover, a few chapters on what may be called the fundamental physics of the home. Although the book applies particularly to American practice, the majority of the subjects dealt with present aspects which are common to all countries, and it may therefore be commended to English people who like to know the why and wherefore of things.

Locomotive Valves and Valve Gears. By Charles S. Lake and A. Reidinger. London: Percival Marshall and Co., Ltd. 1940. Price 5s.—We would commend this little book in any case out of hand because it spells Walschaerts correctly when so few people do, but as a matter of fact it has yet other merits. It is essentially a descriptive book and one may find in it clear drawings and diagrams of all the familiar locomotive valve gears that are still in use, and of one or two that are now rarely met with. There is also a chapter on slide valves, including a demonstration of the Zeuner diagram, and another on piston valves with useful drawings. Cam-operated valves are, of course, dealt with, but the authors have not attempted to discuss the reasons why the type has made so little progress in this country and America. They felt, no doubt, that a book intended principally for the ordinary, not mechanically minded, reader was not the proper place for questions into which many factors enter.

Sixty Years Ago

SIR THOMAS BOUCH

ON October 30th, 1880, Sir Thomas Bouch died at Moffat, Dumfriesshire, in his fifty-eighth year. For several years he had been in ill-health and it was believed that his death was hastened by the fall of the Tay bridge and the consequent abandonment of his other scheme for bridging the Forth. He was born at Thursby, near Carlisle, in 1822, his father being a captain in the merchant service. On leaving school he was apprenticed to Mr. G. Larmer, a civil engineer. His first professional appointment was as resident engineer during the construction of the Wear Valley Railway. In 1849 he went to Scotland as manager and engineer to the Edinburgh and Northern Railway, subsequently the Edinburgh, Perth and Dundee Railway, and later part of the North British system. During his tenure of this office he spent much time seeking to improve the transit of goods wagons across the Forth and Tay ferries and eventually developed a system of train ferries. In 1851 he set up in business in Edinburgh as a civil engineer and received extensive employment on the construction of numerous short railway lines in Scotland and on a number in England. In 1858 he constructed a stone pier and lattice girder bridge across the River Tees. Thereafter he devoted a considerable part of his attention to bridge building, notable works which he designed or which were attributed to him being the Deep Dale viaduct, the Beelah viaduct, the Redhaugh bridge at Newcastle and the Bilston viaduct. It would appear that in some at least of his works his name was given greater prominence than the circumstances warranted. During the course of the Tay bridge inquiry, for instance, it was revealed that the detail design of much of it was done by an assistant. Again, it is on record in the "Proceedings" of the Institution of Civil Engineers that the idea of establishing train ferries across the Forth and the Tay originated with a Mr. Grainger and that the scheme was carried out by Mr. W. Hall under Bouch's name. The Hownes Gill viaduct, another work with which he was credited, seems to have been designed by himself, but the design was submitted to Robert Stephenson, who altered it considerably in order to increase its stability. The Beelah viaduct, constructed under his name, was designed by Mr. Robert H. Bow. He appears to have used rough rule-of-thumb methods in such designing as he actually did, and when challenged could not give very clear reasons for "putting a bit on here or taking a bit off there." He was knighted by Queen Victoria after her Majesty had passed over the Tay bridge on her way to Balmoral. With the collapse of that structure Bouch's reputation as an engineer, which he had acquired in spite of the facts briefly alluded to above, rapidly disappeared and the Forth bridge project, "a preposterous, ill-advised and ill-considered piece of business," as we described it in the obituary notice which we published in our issue of November 5th, 1880, was abandoned.

ANNUAL ELECTRICITY STATISTICAL RETURN.—The Electricity Commissioners have decided, as a war emergency measure, to reduce as far as possible the amount of information to be rendered by authorised undertakers in their annual statistical return for the year 1939–40 Although the Commissioners have found it necessary to adhere to their previous decision to defer publication of further statistical volumes during the war, they, nevertheless, regard it as important that continuity of the main statistics of the supply industry should be preserved so that publication can be resumed after the war. The Commissioners accordingly trust that all undertakers will continue to maintain their statistical records as fully as the circumstances permit.

Ancient Harbours*

No. I

The Four Harbours of Alexandria

SHIPBUILDING and harbour engineering are two of the oldest branches of our profession. It is well established that before 3300 B.C. the Egyptians built sea-going ships and that they made voyages to far lands to procure iron, lead, silver and other materials; and it is recorded on the Palermo stone that about 3000 B.C. King Seneferu built sixty great ships to go to the Syrian coast to bring cedar wood for his works. The terminus of these voyages was on the Canopic branch of the Nile, where was situated A-ur, or the Great Door, which Mr. P. E. Newberry calls "an ancient Alexandria of a period earlier than 3000 B.C." Little is known about this harbour, except that Narmer, one of the earliest kings of the First Dynasty, considered it of great importance and decided to conquer the petty kingdom of Harpoon to which it belonged. It was an inland port and probably had the disadvantages of that type, especially as it lay on the banks of an arm of the delta. The actual site of the port is not known, but I refer to it because it is the earliest harbour of which I have found mention and because it marks the beginning of the harbour of Alexandria, which, I think, has the longest history of any harbour in the world. I propose to devote some of my time to a study of the great schemes adopted on the Alexandrian site over a period of nearly 5000 years (Fig. 1). There have been four distinct harbour building periods—the harbour of A-ur, about 3000 B.C.; the great harbour of Pharos, soon after 2000 B.C.; the harbour of Alexander the Great, begun in 332 B.C.; and the modern harbour, which dates from A.D. 1870.

The Great Harbour of Pharos (Fig. 2) was typical of the pre-Hellenic form of massive structure, far more massive than some of the great harbours of modern times, and it is well worth study. Its lay-out and the skilful use made of the configuration of the bed of the sea might have been the work of a modern harbour engineer. When, says Monsieur Gaston Jondet, "one examines the largeness of the project and ponders on the boldness of its execution, it becomes obvious that it was conceived by a sovereign power of unequalled breadth of view, a realistic genius capable of conquering and keeping the mastery of the Mediterranean Sea." Who the realistic genius was we do not know, for Egyptian history, curiously enough, has no record of this harbour. Monsieur Raymond Weill attributes both its conception and its construction to the Minoan Cretans, who at that time were the greatest sea-faring power in the Mediterranean. It could not, however, have been made without the co-operation of the reigning Pharoah, possibly Senusret of the Twelfth Dynasty, a famous builder of colossal buildings typical of the Egyptian, Minoan and Mycenæan civilisations of those early times. This gives us a date somewhere between 2000 and 1800 B.C.

The harbour was based at its eastern end upon the island of Pharos, and at its western on the rock of Abu Bakar. It also took advantage of the submerged ridge running from Marabout point to the north of Pharos, and of the shelf which sloped from this towards the deep sea. From the bay of Ras el Tin at the western end of Pharos to the Abu Bakar rock there is a deep pool, bounded on its northern edge by the submerged ridge. It was by surrounding this pool with breakwaters and piers that the great inner basin was formed. Seawards of this, another series of breakwaters, using the outer edge of the shelf, enclosed the outer basin. The two basins together formed a magnificent harbour about 300 acres in extent.

The entrance to the harbour was on the south, and the approach channel crossed the submerged ridge by the Passe des Corvettes between the Ikvan and El Dublan rocks. Between these rocks the southern boundary of the harbour, and the island of Pharos, not then joined to the mainland of Egypt, was a sheltered roadstead for ships making the entrance against the prevailing north-west wind.

* * * * * *

It may seem strange that when Alexander the Great founded Alexandria and built his harbour in 332 B.C. he should have taken no notice of these wonderful works. The reason was that they had disappeared under the sea, and all that marked the site of the future city was a little village at Rhacotis and a small colony of fishermen. There is no more record of its fall than of its rise. Homer may refer to it in the fourth book of the "Odyssey," where he describes Pharos as an island in the troubled sea having within it a haven with fair moorings. If this is so, then its decline must be dated some time after 1000 B.C.

A few words as to the cause of its disappearance may be interesting, although "disappearance" is really a misnomer, because, as Monsieur Jondet has shown, a very large portion of the works still exists and on a calm day parts of them can be seen clearly below the surface of the sea. The ridge of high ground upon which the harbour was built is formed of limestone similar to that exposed in the quarries of Mex. Overlying the slopes of this ridge is a thin layer of clay, upon which is a thick layer of river silt in various states of consolidation. Covering this on the higher slopes is the stratum of hard argillaceous sand, and it was upon this that the walls and breakwaters were built. Monsieur Jondet considers that, as the silt consolidated, its bearing value weakened and the stratum of sand which rested upon it glided down the slopes in sudden subsidences, the underlying clay acting as a sliding surface. The process was purely mechanical, although earth tremors may at times have

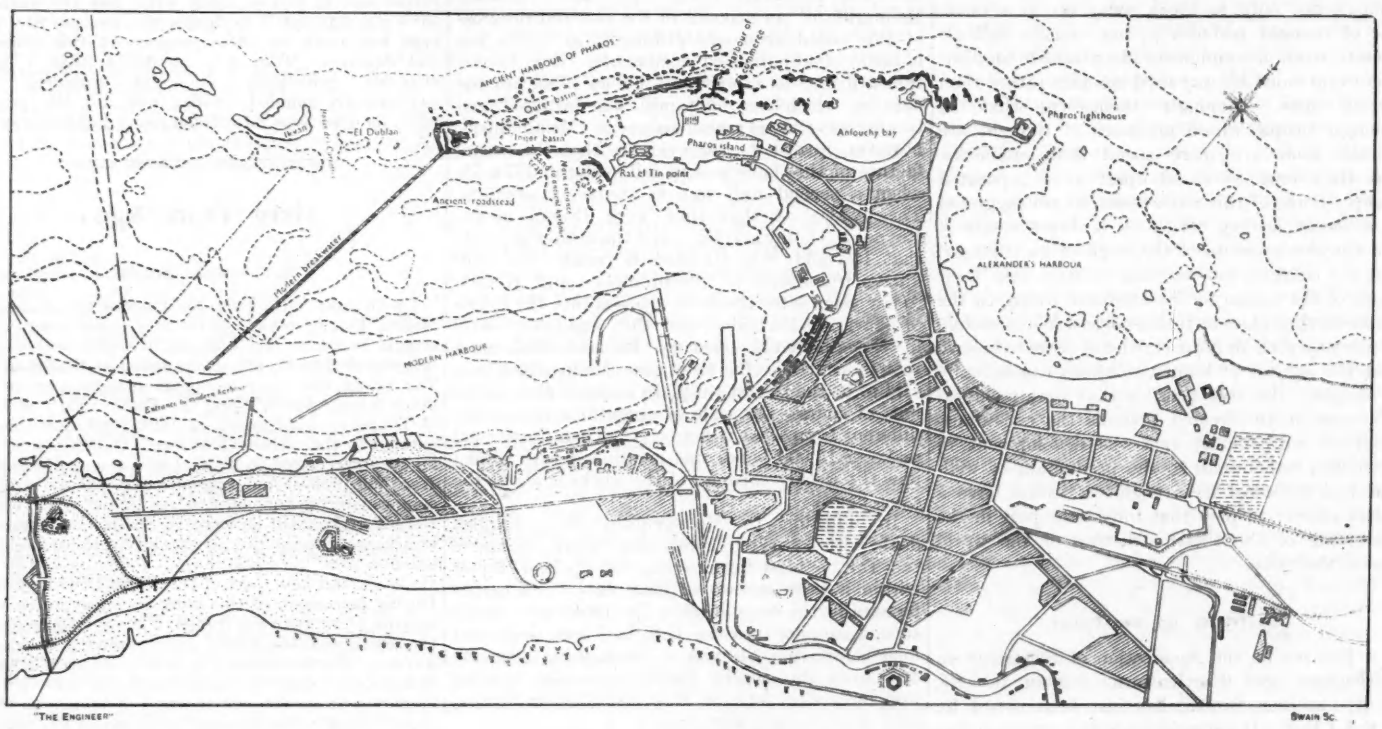


FIG. 1—MAP OF ALEXANDRIA

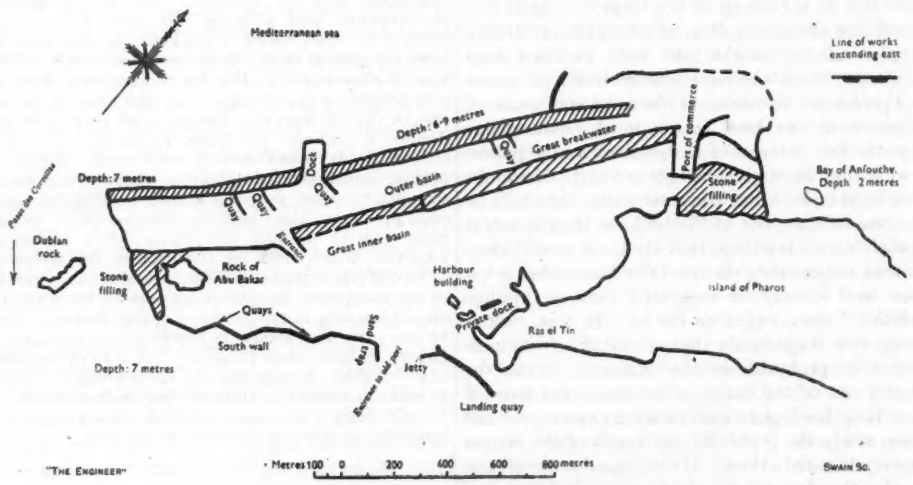


FIG. 2—THE GREAT HARBOUR OF PHAROS

* From the Presidential Address of Sir Leopold Saville to the Institution of Civil Engineers.—November 6th.

started the movement. In this manner whole portions of the works glided below water level, often without any damage to their structure.

Fifteen hundred years after the foundation of the harbour of Pharos, Alexander the Great, returning down the Canopic branch of the Nile from his visit to the temple of Zeus Ammon in the oasis of Siwah, halted at the village of Rhacotis. Ever since his destruction of Tyre he had determined to build a harbour that should be her rival. At Rhacotis he had found the place he wanted. He, himself, is said to have traced the plan of Alexandria and its harbour, which his famous engineer, Dinocrates, was ordered to carry out (Fig. 3). The main feature of

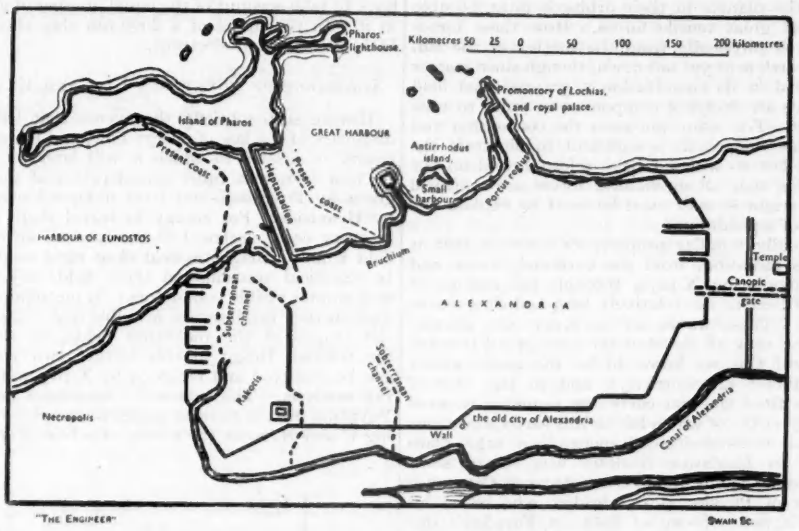


FIG. 3—ALEXANDER'S HARBOUR AND CITY

the harbour was the great mole, 600ft. wide and 7 *stadia* (about 1 mile) in length, and hence called the *Heptastadion*, from the mainland to the island of Pharos, which divided the roadstead into two basins. It was built in a depth of water of 36ft., and its construction entailed the excavation, transport and deposition of about 2 million cubic yards of stone. The basin on the right of the mole formed the Great Harbour, and that on the left the *Eunostos* or Haven of Happy Return. Two openings through the mole connected them, thus conforming to the ancient rule that a harbour should have two entrances. The Great Harbour was bounded by the Lochias headland, the *Heptastadion*, and the eastern end of the island of Pharos.

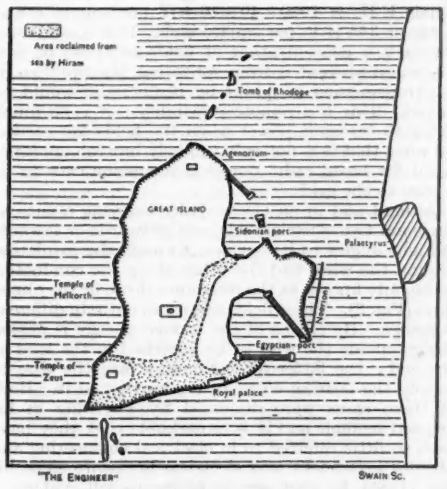


FIG. 4—EARLY MAP OF TYRE

Seaward it was protected by a pier built out from the Lochias and by a line of dangerous reefs, which made entrance to the harbour difficult. It was chiefly to remedy this that Ptolemy built the world-famous Pharos, or lighthouse, one of the seven wonders of the world, on the eastern point of the island. Alexander erred in putting his harbour in this place, since the depth of water was not so good as in the neighbouring haven, the reefs and Lochias pier did not provide sufficient protection against the winds, and the entrance was always difficult. Within the Great Harbour lies the small island of Antirrhodus, and between it, the mainland, and Lochias was formed a small *Portus Regius*, or Port Royal, for the king's ships. Between the *Portus Regius* and the *Heptastadion* the shore was lined with quays and storehouses. The public granaries were on the *Eunostos*, where also was a small inner harbour enclosed by piers. It was on this basin that the important canal connecting the harbours with Lake Mareotis and the Nile, by its Canopic branch, opened. Alexandria partially fulfilled its founder's purpose of crippling the trade of Tyre; but this was due to the policy of Ptolemy Philadelphus (285–247 B.C.), who made a harbour at Berenice on the Red Sea, connected it with Coptos, on the Nile, by a road provided with water places at proper stages, and reopened the canal between the Nile and the Red Sea at Suez. Thus he captured for Alexandria the important trade of the Indian Ocean and the Red Sea, which had hitherto passed by Eloth and Eziongebir to the coasts of Palestine, whence it was carried in Tyrian ships over the whole of the then known world. Alexandria's gain was Tyre's loss.

A period of more than 2000 years passes (Fig. 1). In the meantime the sand, which the engineers of ancient Pharos had been so careful to fend from the entrance to their harbour, had passed along the roadstead and had been caught up by the *Heptastadion*. Gradually it broadened until it formed that belt between the waters upon which a large portion of the modern city of Alexandria is built. The engineers of 1870 discarded Alexander's great harbour, which had been for many years too difficult and shallow for shipping, and the entrance to which was still dangerous and difficult to make. They returned to the western side of Pharos and their great breakwater, like the south mole of the ancient harbour, was based on Ras el Tin. The modern harbour occupies what was the roadstead of its predecessor of 4000 years ago.

TYRE

Tyre was another famous pre-Hellenic harbour (Figs. 4 and 5), but it is only a few years ago that a true plan of its works was published by Père A. Poidebard. As a result of three years' research, from 1934 to 1936, in which he made brilliant use of aerial observation and photography, coupled with submarine observation and photography, Poidebard was able to demonstrate the incorrectness of all previous plans and the unreliability of any plan made of ancient works unchecked by careful research and observation on the spot.

Tyre had two harbours (Fig. 5), the Sidonian on the north of the island and the Egyptian on the south, and, like Pharos, a spacious roadstead to protect ships from the stress of the open sea when making the entrances. The Sidonian was what the ancients called a closed (*kleistos*) harbour; that is to say, it was within the circumvallation of the city and its entrance could be blocked by suspending a chain from one side to the other. The Egyptian was an open (*aneimenos*) harbour, outside the fortifications but adjoining them.

Tyre was a very old city, dating back, according to Herodotus, to 2750 B.C. This is probably incorrect, but at all events by 1400 B.C. its renown was widespread, and by 1100 B.C. its seamen had passed Gibraltar and had dared the Atlantic. It was probably about this time that the Sidonian harbour was built. Hiram, king of Tyre (970–936 B.C.), friend and ally of Solomon, was a great builder and engineer. When he came to the throne Tyre was separated into three islands by arms of the sea full of reefs. Hiram filled these channels and on part of the land so reclaimed built the Egyptian harbour, not as Maspero and others have asserted, on the south-east of the island, but, as Père Poidebard's discoveries have shown, along its south coast (Figs. 4 and 5). A massive mole, 2500ft. long, runs from the south-east corner to a large exposed rock lying off the south-west corner. Two similar moles, one running northwards from the rock at the end of the south mole, and the other running southwards from the shore of the island, enclosed the harbour on the west. The ends of these walls overlapped so as to form a protected entrance from the open sea to the western basin.

Two marked advances had occurred in constructional methods since the days when Pharos was built, namely, the use of concrete in making sea walls, and the use of iron dowels run in with lead. Both of these methods were used at Tyre.

The moles were very solid structures. They had foundations of large, hewn, rectangular blocks, all laid as headers. The middle was composed of hard concrete divided at intervals into compartments by transverse bonding. The side bordering the sea was faced with square slabs, 10ft. long by 4½ft. thick, laid as stretchers. The south mole varied in width from 24ft. to 26ft., whilst the two western moles, which had to face the full force of the sea, were 7½ft. wider.

In the middle of the south mole was the main entrance to the harbour, and from each side of it two large wharves, built of concrete and faced with stone, were built across the interior for about two-

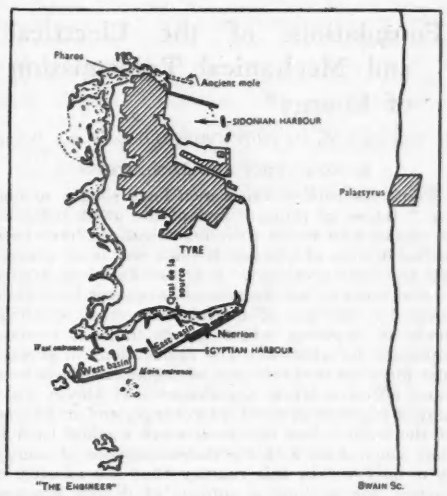


FIG. 5—POIDEBARD'S MAP OF TYRE

thirds of its width. The narrow passage thus formed was commanded by a fortified post on the island. This passage was the boundary between the western and eastern basins.

A concrete wharf, the *Quai de la Source* on Père Poidebard's plan, cut the eastern basin into two, the farther and smaller one of which appears to have been paved throughout with flagstones and to have been used as a *neorion*, or shipbuilding and repairing yard, equipped with slips and storehouses. Père Poidebard thinks that it may have communicated with its neighbouring basin by means of an inclined plane, but Monsieur Berthou thought it had direct access to the sea. Possibly both methods existed. At the northern corner of the outer eastern basin, where the *Quai de la Source* abuts the island, was a small basin which accommodated a drinking water tank for replenishing ships—an important item, for water was precious in Tyre, nearly the whole supply of the island having to be brought across by boat from springs on the mainland.

The Sidonian harbour made use of a small bay at the north-east side of the island and was partly surrounded by the city. Two jetties, one jutting out from the ancient tower near the modern lighthouse and the other coming from the opposite side in a northerly direction to meet it, protected its entrance. Père Poidebard was able to trace the northern jetty and thus to prove that it lay some distance beyond the existing jetty of Sur and that the ancient harbour was larger than the modern. The construction of the jetties was similar to that of the moles in the Egyptian harbour.

Old authorities record that the two harbours were connected by a canal, and many old plans show this canal, but it is not shown on Père Poidebard's plan, or on Berthou's, made in 1846. It is, however, possible that there was communication through the arm of the sea said to have been reclaimed by Hiram. It was a common custom in

ancient harbours to have two separate but interconnected basins, and Sidon, which also belonged to the Phœnicians, was laid out on this plan, which had obvious advantages. Vessels could enter one of the basins when a contrary wind prevented them from entering the other; if one basin was made unsafe by a storm ships could move through the canal and take refuge in its neighbour; whilst if an enemy attacked he would have to split up his fleet or risk being surprised by the defenders, who, having escaped through the other entrance, might attack him in the rear.

* * * * * *

Five hundred and eighty years after the death of Hiram came Alexander the Great. Tyre, unconquered still, was too great a danger to leave behind him while he was away subduing the East. Alexander's fleet was too weak to fight her at sea. Nothing daunted, he attacked from the land, and for this purpose he built a colossal mole, 100ft. wide and ½ mile long in 3 fathoms of water, so that Tyre ceased to be an island and became a peninsula. He demolished the old city of Palætyrus for stone and robbed the forests of Lebanon for timber to accomplish his purpose. In nine months he completed his task and captured the city. The laws of Nature asserted themselves; coastal drift completed what Alexander began, and now Sur, the ancient Tyre, is connected to Syria by a broad neck of land.

(To be continued)

Foundations of the Electrical and Mechanical Transmission of Energy*

By Professor W. M. THORNTON, O.B.E., D.Sc., D.Eng.

Introduction and Definitions

From the earliest times men have sought to find the "nature of things," and of the great branches of science into which their investigations have been gathered that of physics is both the most general and the most profound. It is essentially an experimental science, but its greatest advances have been made by the use of mathematics, that symbolic mode of thinking which at its highest requires supermen to wield it. The applications of physics that form the scientific part of engineering have been most effective when experiment and theory have moved together in rapid interchange, and in no part of the subject has this been more marked than in that which deals with the transformations of energy. It is only within this century that the identity of energy, for so long a subject of debate amongst scientists, has been firmly established. It is as real as matter itself.

The ten years between the discovery of X-rays by Röntgen in 1895 and Rutherford's establishment of the electrical constitution of matter have been described as the most fruitful in the history of science. To this amazing period we owe X-rays, the discovery of the electron, radioactivity, radium itself, relativity, the quantum theory of radiation, the development of radio communication, and the discovery that atoms are hollow planetary systems of elemental charges of positive and negative electricity, the proton and the electron. This last, together with the relation that is a consequence of the theory of relativity, that matter is a form of energy, so that mass, electricity, and energy are convertible terms, places the doctrine of the identity of energy on a firm basis of reality.

The term energy as engineers know it and use it is defined rather vaguely as the power of doing work. It is not a good definition, but we may accept it as sufficient for our purpose. In order to possess this power, the body or system of bodies in which energy for the time is located must either be in motion, in which case the energy that it has by virtue of its motion is called kinetic, or be part of a state of elastic strain, when it is termed potential energy or energy of position. A weight when raised acquires potential energy from the added elastic strain of the ether of space that carries gravitational forces.

In order that energy should be transmitted from one place to another it must be transformed from one of these states to the other, and the means by which this is in general done is the problem to which I propose to direct your attention. It is a problem of great theoretical and some practical interest, and though the operations of engineering can well be carried on without a deep knowledge of the physical foundations on which they depend, it is well to know that such foundations exist and, further, that there is one law governing the whole range of the transmission of energy, whether in electrical or mechanical engineering. This law is little known and is rarely referred to. Though occasionally used in the solution of electrical problems it has never hitherto been applied to the consideration of those which deal with the transfer of energy by mechanical means.

There are problems of the transfer of energy which are met daily to which as yet there is no complete answer. How, for instance, does a pendulum work? At the end of its swing the energy is all potential, in the middle it is all kinetic. There is an almost perfect conservation of energy, but no one knows how the transformation takes place from the one form to the other. Its complete solution would require an understanding of the physical nature of gravitation and of the ether that has evaded scientific research from the time of Newton and the apple.

One property of gravitational space that we as engineers may accept without question, though there are mathematical dodges to evade it, is that to hold the planets in their orbits it must be able to support great tensile forces. How these forces are derived physically from the matter of the sun and the earth is as yet unknown, though since matter is electrical in its constitution a gravitational field must have an electrical component in order to take hold of it. For many purposes the conception and use of this component is sufficient to illustrate the universal law to which I have referred, and on the assumption that all mechanical forces are electrical in their origin it may even be used to explain the working of a pendulum.

An equally familiar property of space is that it transmits radiation, from the extremely short and rapidly oscillating X-rays, through the regions of light and heat to the relatively long and slow waves of radio. These waves are in every case electromagnetic; they all travel at the same speed through space (and this we know to be the most perfect non-conductor of electricity), and in the case of radiation from the sun carry the immense thermal energy by virtue of which life on this earth is possible. How this transmission of energy can take place through an insulating medium was shown some seventy years ago by James Clark Maxwell, Cavendish Professor of Physics at Cambridge, who based his electro-magnetic theory of light on Faraday's discovery of magneto-electric induction and on the polarisation or strain of insulating materials of dielectrics in an electric field of force. Maxwell's theory led in the end to the invention of radio, and brought the Antipodes within reach of a telephone call. But even Maxwell, though he had found by mathematical analysis the velocity with which electro-magnetic waves travel in space—that is, the velocity of light—and knew that both the electric and magnetic fields in these waves were transverse oscillations of the ether at right angles to one another, did not find or state the law connecting them and the mode of transmission of their energy. This was done some twenty years later by Professor J. H. Poynting, who in extending Maxwell's theory, derived the simple and powerful relation now known as Poynting's theorem or law. Stated briefly, this is that everywhere in Nature energy flows by the mutual reaction of electric and magnetic fields, that it is delivered in a direction at right angles to the plane containing both of them, and that the power is simply proportional to the product of the fields. This law controls the passage of every form of electrical or mechanical energy, and now that we know that there is nothing in the material universe but electricity, it may even be regarded as one of the most illuminating physical relations in Nature, since electricity or electrification moves everywhere according to this rule.

Fields of Force

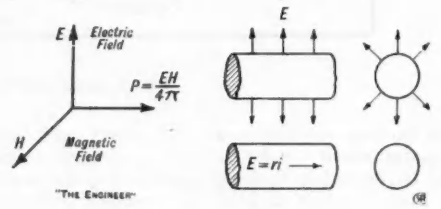
A field of force in physics is a state of stress that is in its origin electric or magnetic, an attraction between unlike charges or poles and a repulsion between those of the same sign. When there is attraction there is a tension along the field and a compression at right angles to it, and these mechanical forces are set up by the essential action that is the nature of the field. There are no known means of causing tensions or compressions in free space except by electrical or magnetic action. Since we know that twisting a cord puts it both in tension and lateral compression, it suggests that such fields may be essentially states of rotational stress in the ether caused by the presence of charges that have themselves a rotational structure. This may be no more than a conjecture; but that electrons and protons have, as is known, their own magnetic fields, which are always rotational or circuital, implies that there is in them an intrinsic rotation, possibly of vortex tubes of the ether, which still awaits full solution. Whatever their form and nature may prove to be, there can be no doubt that on the forces between protons and electrons, when gathered together into their closest union, the whole fabric of the material universe depends.

The Electrical Constitution of Matter

The electrical theory of the constitution of matter, propounded by Rutherford, is that atoms of ordinary matter are minute systems of electrons in extremely rapid rotation around a central region or nucleus which, though it also contains electrons, except in the one case of hydrogen, has more protons or units of positive charge than electrons and has therefore an electrically positive sign. This is surrounded by an active shell of negative electrification, the total charge of which is equal to that of the nucleus to which the electrons are held by the electric attractions between them, and there are in all ninety-two such elements from hydrogen to uranium. The atomic constitution of the matter of the most remote stars is revealed by their spectra and in the universe there appear to be no other elements but these that are known in our small bit of it. With the masses of the two fundamental charges we are not now concerned, but that of the proton is nearly 1850 times greater than that of the electron, so that for most practical purposes the mass and kinetic energy of moving bodies is due to the positive charges they contain. The weight of a small ship and its cargo could without sensible error be expressed, instead of in tons, in protons, but that of a large ship would have to take account of the equal number of electrons in it. In the metal of a 2000-ton ship there are a little over a ton of electrons.

Statement of Poynting's Law and Examples

Having stated briefly the events that led to the discovery of the law of energy flow, and the electrical theory of matter to which it will later be applied, we now turn to a fuller consideration of the law as given by Poynting, and later independently stated by Heaviside. For energy to travel there must be in every case, electrical or mechanical, an electrical field E and a magnetic field H at right angles to it. In electrical transmission these fields are between and around visible conductors; in mechanical transmission they are between invisible molecules, though the shapes of the molecular fields, as shown by Sir William Bragg in this lecture two years ago, can be observed and recorded by X-ray and cathode ray analysis. The power P, sometimes called the Poynting flux, is at right angles to the plane containing E and H, as at the corner of a box (Fig. 1), and



FIGS. 1 AND 2

is equal, numerically, through unit area to the product $E H/4\pi$. In high-voltage systems the electrical field is much the greater of the two, in low-voltage transmission the magnetic field may be the greater. The electrical field is usually expressed in volts per centimetre, the magnetic field either as 4π times the ampere turns per centimetre, or, dropping the 4π, simply as the ampere turns. Thus, if in the same element of space there is a field E of, say, 1000 volts per centimetre, and a magnetic field H of 40 ampere-turns per centimetre the energy flux P which then equals E H, is $1000 \times 40 = 40$ kW per square centimetre or 345 H.P. per square inch. If we could ever get such a concentration of fields as these in free space and prevent it from spreading, the problem of the transmission of power by beam radio would be solved. This is a remote possibility; it is so much easier to transmit power when the fields are carried by wires that it is not only unlikely but too uneconomical for beam radio power transmission ever to be a rival to the grid.

Around and in an electric wire carrying a current there are two electric fields, one outwards or inwards at right angles to its surface, through the insulation around the wire, and the other along the conductor, commonly known as the resistance drop, or the ohmic drop (Fig. 2). These fields serve two entirely different purposes. By means of the former, energy is passed along outside the wire to be absorbed in the load at the end; the latter directs energy into the wire to supply the heating effect of the current in it. Both of these cases were discussed by Poynting in his original memoir and it is remarkable that they have been so little referred to in electrical engineering and physics text-books and electrical literature since his day (1885), for they are by no means self-evident.

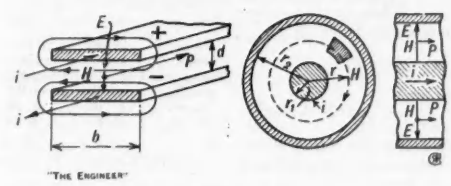
Applications of the Law

There are certain elementary relations known to all students of electricity; for example, that power in watts is the product of volts and amperes. This to a student of mechanics may seem self-evident, for voltage is pressure and amperes are flow measured in quantity of electricity per second, and the product of pressure and rate of flow is power. It might be said that this is only a mechanical analogy, though quite adequate. To prove it by Poynting's law, consider the case of two flat strips of breadth b at a distance d apart, the "go and return" of a current i (Fig. 3). The magnetic field (lines per unit area) between them is in the appropriate units $4\pi i/b$. When the voltage between them is V the electric field $E = V/d$. The power passing through unit area of the space between the strips is then $p = \frac{i}{b} \cdot \frac{V}{d}$. The

* North-East Coast Institution of Engineers and Shipbuilders, the Ninth Andrew Laing Lecture.

area between them is $b\,d$, the total power transmitted is therefore $P = p \times \text{area} = \frac{V\,i}{b\,d} \times b\,d$; that is, the product $V\,i$.

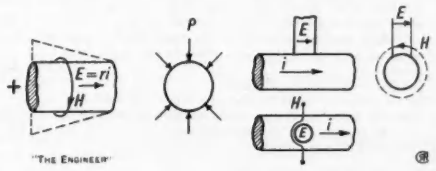
Many older electrical systems of mains in London and on the Continent are formed by strips of bare copper carried in this way on porcelain insulators, with no other solid insulation between them. Modern high-tension cables have a cylindrical sheath of solid insulation of very high quality around the conductors which can easily carry an electric field of 10,000 volts per centimetre. In such a case, with a magnetic field at the surface of a conductor having a value of 100, the power carried is $10{,}000 \times 100 = 1000$ kW per square centimetre. This intense concentration of power is not in the wire but in the paper or rubber, or whatever the insulation may be. No power is transmitted through the wire. Any electro-magnetic



FIGS. 3 AND 4

energy that enters a metal never comes out of it except as heat or in the case of machines as mechanical stress. The manner of the power flux is as follows :—

In a single-core cable the electric field E is at right angles to the surface of the conductor, the magnetic field is around it, and the direction at right angles to both of these is along and through the insulation parallel to the axis of the conductor. The whole of the energy transmitted travels as a cylindrical stream in the insulation between the inner and outer conductors (Fig. 4). There are no exceptions to this law of transmission by insulation. The reason why electrical conductors are insulated is to enable them to be surrounded by a high electric field by and through which they can pass energy along to the end of the line. The energy supplied to an electric lamp hanging by flexible wires reaches the glowing filament through the rubber insulation—none of it through the copper wire. The sole use of the wire is to carry a current in order to provide a sustained magnetic field by which the stream of energy can be maintained through the electric field in the insulation. The heating of the lamp filament or any conductor that is caused by the flow of the current in it is a combination of effects. A current consists of a vast number of electrons streaming through the wire, forced along by the circuit voltage. They collide with the molecules in the crystal framework of the metal, and since this framework is not quite rigid it gives way a little at every collision. In doing so it takes energy from the electrons and slows them down, but the energy of molecular vibration increases because of the impacts, and the wire gets hot. To maintain the current there must be, because of this absorption of energy, an electric gradient along the wire. There is, while the current flows, a magnetic field around the circumference, and the direction of the flux of power caused by these two fields is at right angles with the surface (Fig. 5). All the energy appearing as heat in the wire, as in a lamp filament or radiator element, enters through the surface of the wires sideways in this manner. Because of the drop of voltage due to the resistance of the wire, the positive end is at a higher potential than the other, so that there is a field in the space around the wire parallel to the voltage drop in it, which has



FIGS. 5 AND 6

a maximum value at one end of the resistor and is zero at the other. It is by the relaxation of the potential of this external field that energy enters the conductor from it to supply the heating loss.

Returning for a moment to consider the means by which energy is transmitted without absorption along a conductor, when carrying current, it is an axiom of mechanics that where energy is transferred there must be force exerted and that the place of its application must move. It is, again, an essential part of Maxwell's theory that when there are both electric and magnetic fields superposed at right angles in an element of free space, there is a resultant strain that travels away from the source of the disturbance at the velocity of light. In order to establish this relation mathematically it is not necessary to know the physical nature of the two fields, but in order to form a picture of the mode of transmission of energy either in space or along a conductor, it is desirable to go beyond the mathematics and to imagine how the fields can react on one another. We know without doubt that the magnetic field around a current in a wire is a state of strain that is elastic in the sense that as soon as the current is cut off it relaxes, and shrinks towards the wire. We may conceive this field to be caused by the sweep through the ether which permeates the wire of countless loop-shaped electron charges spinning as they advance ; but whatever its nature may ultimately prove to be, it is a sustained strain. We have seen that an electric field is most probably a rotational strain in the ether. Now, in the space around a wire carrying a current, both of these fields are superposed at right angles and the plane of rotation of the electric field is also that of the direction of the magnetic field. How do they react on one another to hand on the electric strain to the end of the line where, as it relaxes, work is done ? A magnetic field is distorted by that of a current placed in it. This is the essential action in an electric motor, and by the reaction on the conductor the force is provided that drives it. But there is no such visible evidence of the reaction between an electric and a magnetic field, for in the first place any distortion could not be seen, and, further, when it is left to itself the displacement vanishes at the velocity of light. Whatever the resultant combined strain is, we know that by its relaxation in a direction away from the sending end, where the strain is continually renewed by the generator, energy flows to the far end of the line. To repeat the argument, when the line is made live, but with no current passing, there is an electrical field from or to it, that is, we conceive, a steady rotational strain in space. When the load is switched on and a current flows, its magnetic field passes through the electric field at right angles to it, so that its characteristic strain is added to that of the electric field, distorting the latter, forcing it towards the receiving end of the line (Fig. 6). When two magnetic or electric fields are superposed in the same plane, we know that there is a resultant force set up by their reaction. When a magnetic field crosses through an electric field at right angles to it, there is, as Maxwell showed, a similar distorting mechanical force set up by which energy travels, though the theory of the mechanism is more complicated than with magnetic fields alone. There is a difference of energy potential along the wire, in the space around it, and this we shall now see is in the same direction on both the positive and negative mains.

(To be continued)

Electricity on the Farm*

By C. A. CAMERON BROWN

THERE are in Great Britain 448,481 agricultural holdings of over 1 acre in extent. Various estimates have been given from time to time of the number of these holdings which are served with electricity from supply undertakings. An analysis of available returns for 1937 made by the statistical branch of the Electricity Commission showed that some 28,000 farms were returned as being connected. Allowing for certain incomplete returns and for the likelihood that some of the smallest suburban holdings may not have been returned as "farms connected," there is good reason to believe that by 1938 the total number of farms connected was over 30,000. As this is only some 7 per cent. of the total number of holdings, it might appear that progress in the electrification of British agriculture has been relatively negligible.

Further practical examination of the subject, however, discloses a more favourable aspect. Of the total number of agricultural holdings in the country a considerable number are grouped together for working from common farm premises, and many of the smallest have no premises at all. Bearing this in mind, and recognising that there must inevitably be a substantial number of farms so situated as to be outside any practical supply scheme, it is probable that the true number of farm premises which might well be considered within eventual and reasonable reach of a supply scheme is of the order of 250,000 at the most ; 12½ per cent. of these have already been supplied. Nor must it be forgotten that, while the average population density of our rural areas may be high, this is largely contributed to by the densities in the immediate neighbourhood of large towns, and that there are very few parts of the rural area proper where a square mile will be found to contain more than fifty to sixty people. It is a feature of our landscape that our farms are detached and isolated from each other by distances as considerable in many cases as one-half to one mile. This is a condition not always appreciated in comparison with conditions in, say, Denmark or North-West Germany ; the use of the term "isolated" in describing the disposition of the farms there means rather that they are not placed together in groups. Their separation is, however, by but a short distance, and a gap of as much as a quarter of a mile between farms is unusual in these districts.

A significant indication of progress is the total number of tractors in this country used for farm work ; Culpin in his recent book gives this as 46,000 (Bib. 107). Since many farms have more than one tractor it is probable that the number of farms with tractors is little more than 30,000—the same proportion as those electrified, and this in spite of the many tractor displays and demonstrations, and a large part of the time of one research institute having been devoted to a study of tractor use and performance for fourteen years.

There is left then for consideration the problems affecting supply of electricity to an outstanding 220,000 farms, more or less, in Great Britain.

THE NATURE OF THE PROBLEM

The problem of the present and the future is the bridging of the gap between the cost of giving a supply to those 220,000 farms and the securing of an economic return to the supply undertaking.

The provision of a supply of electricity to farms, other than from a low-voltage network, does not appear to be a lucrative undertaking. A rough verbal inquiry in different parts of the country would appear to show that the average annual revenue per farm is something under £25. In many cases, indeed, this average figure is only reached by the help of one or two large, prosperous and possibly "luxury" farms giving revenue up to £150 each. Mr. Pickles, again, has shown the average return from 551 farms to be £12 4s. (Bib. 3) ; he did show, however, that in the case of seven farms the additional revenues from attached farm cottages, representing for all practical purposes the same high-voltage connection, raised the average annual return to £26 8s. 8d.

On the usually accepted 20 per cent. basis such returns as £25 per annum can only justify expenditure on the service up to £125. It is probable that the average cost of supplying the remaining farms will far exceed this, and in many cases by as much as five or six times. It is clear, therefore, that to enable any substantial number of these farms to be supplied, without resort to capital contributions, which are often impossible to obtain and are nearly always a strain on good relations, two ways must be explored :

1. The possibility of lowering the cost of giving supply to isolated farms, by simplification or standardisation or other means.
2. The possibility of increasing the general return to be obtained from farms.

The first way lies outside the terms of reference of this study, but is receiving the attention of the E.R.A. The second way involves co-operation between the electrical and agricultural industries and there is reason to believe that, tackled in a spirit of co-operation directed not to the end of increased electrical sales alone, but to the ultimate good of both industries, the problem will be largely solved in this way.

An increase of the average return to even £30 would be of some importance, and the attainment of a figure of, say, £40 or £50 would change the whole situation. It must be remembered that if the lines on which such increased returns are secured appeal to the farmer, this will mean not only a better basis for future supplies to the remaining farms, but an enhanced return from these farms already connected which will go towards stabilising the position as a whole in rural areas.

THE OUTLINE OF A SOLUTION

An improvement in the general level of returns from farms might be effected in any one of three ways :—

1. By increasing the tariff rates and assuming that no fall in consumption will result.
2. By increasing the consumption without increasing the tariff rates.
3. By reducing the tariff rates and so inducing an increase in consumption which will in due course show an increased gross return.

Method 1 may be ruled out without any discussion as an impracticable policy.

Method 2 is sound policy, and there are many areas where the tariffs offered are promising enough to suggest that concentration on this aspect would result in a considerable improvement in the gross return from farms.

Method 3 would, of course, be the happiest policy for the consumer, and will, no doubt, come into play in due course, but its pursuit lies outside the purview of this report.

Method 2 requires a definite programme of work directed to the study of increasing the consumption of electricity on farms in terms of existing conditions.

Such a programme to provide a successful and permanent solution, must be something more than a discovery and cataloguing of different ways of using electricity on farms. It would be well to pay some attention to the experience of the Americans under somewhat similar circumstances. They now admit that the development of consumption simply with the aim of loading up the lines is fundamentally wrong, and that the best way to achieve this end is to concentrate on developing electricity as a beneficial tool in the hands of the farmer—the increase in electrical loads will follow.

Labour shortage is a recognised and increasing difficulty in farming, and electricity's most vital appeal has lain in its labour-saving potentialities. It is therefore suggested that consideration be given especially to the art and technique of labour-saving

* Excerpt from a Report on the Application of Electricity to Farming and Horticulture, published by the British Electrical and Allied Industries Association. Price 2s.

on the farm, in terms of the capacity of electricity to effect this.

Something more is required than attention to individual and detached applications. Indeed, the introduction of one labour-saving appliance on its own may result in a merely temporary and embarrassing freeing of labour for which there is for a short time no convenient use. What is required is a study of "farmyard husbandry," leaving for the time the use of electricity on the land, welding together into a harmonious whole the different perfected individual applications.

Such a study would involve work somewhat along the following lines :—

1. Research and experimental work on individual machines and appliances to determine—

(*a*) In which way the individual requirement can best be met electrically on absolute grounds.

(*b*) In which way this solution may have to be modified to conform to farm conditions and limitations.

(*c*) The cost of carrying out the process electrically.

2. Experimental work to develop the technique of using the different machines and appliances in the whole work of the farm, to enable the advantages developed in each to contribute to the advantage of the whole arrangement.

3. The conveyance of the results of 2 into practical trial on commercial farms and the study of the behaviour there of methods developed under, perhaps, the more favourable experimental environment.

It is contemplated that, if such a scheme is undertaken, the work in Section 1 would be carried out largely by, or in close conjunction with, the agricultural research institutes concerned in the particular agricultural process involved. The work would take largely the form of laboratory work in conjunction with tests in the experimental workshop, and eventual trial in a farm building. Work in Section 2 would probably best be carried out on the farm of an experimental station where interference with the running of the farm is an expected occurrence, and is allowed for in their plans. Alternatively, there are a few farmers who are always willing to put up with a considerable interference with their routine for the sake of experiment and progress. Work in Section 3 would be carried out on private farms, and, in at least the first stages, farmers of this type would be asked to offer facilities.

In addition to this progressive scheme of development it would probably be found advisable to proceed with parallel work on the obtaining of basic information, by which the economic success of these developments could be judged. There is, for instance, no really satisfactory information available showing what present dairy heating costs must be borne in mind in putting forward electrical alternatives, or the relation between steam pressure and resultant sterilising performance, or what exact temperature conditions are required in greenhouses. Lack of such information is a difficulty which has to be faced in many other cases where electricity is applied.

It is felt that the work of Section 3 is of particular importance. While, of course, that done under 1 and 2 is fundamental and essential, much of its value would be lost if attention were dropped at the experimental stage. Any developments which take place should be carried forward to the stage of commercial application, where they should be demonstrated. If left at the conclusion of the experimental stage there is a strong chance that the subsequent transference to the commercial stage by disinterested parties may be accompanied by discrepancies which destroy the value of the previous work.

To appreciate what scope there is for work on these lines it is necessary to study in some detail the different agricultural processes in the light of their possible operation by electrical means.

The author would like to express his indebtedness for the assistance given by the many people engaged in agricultural research, administration and teaching who have given valuable information and informed criticism on the different agricultural processes and problems.

MINERALS USED IN WELDING.—A long list of minerals is used in the welding of metals, and each of them has its particular function. The village blacksmith's recipes and the materials he used to assist welding were simple, and at one time no one in the mineral industry looked to welding as an important outlet for his products. With the gas torch and then with electric welding, the picture has changed. Mines such as those producing rutile send most of their output into the welding industry. Fluxes to dissolve oxide coatings from the metals being welded were once the whole stock in trade of the welder. Now the coatings on welding rods for electric welding carry not only fluxes, but arc stabilisers, thickeners or thinners for the welding slags, deoxidisers for protecting oxidisable metals from attack by air, alloying elements to give stronger welds, binders to hold the rod coatings together, reinforcers like asbestos fibre to prevent cracking of the coatings and many other functional ingredients. The fluxing minerals, such as borax, quartz flour, oxidised manganese minerals, fluorspar, and numerous chemical derivatives of simple minerals, like lithium carbonate, ferro-manganese, potassium chromate, and scores of others, all find their market. Asbestos not only acts as fibrous reinforcer for coatings, but supplies magnesia and silica for building protective slags.

New Iron and Steel Prices

THE Minister of Supply has made an Order under the Defence (General) Regulations, 1939, which came into force on November 1st, 1940, and may be cited as the Control of Iron and Steel (No. 13) Order, 1940. The Order brings into force a new range of prices for iron and steel materials as follows :—

MAXIMUM UNITED KINGDOM PRICES FOR IRON AND STEEL PRODUCTS

Unless otherwise stated, prices set out or referred to in this Schedule are basis prices per ton, for the quantity (if any) shown, delivered to buyer. Other prices (related or additional) for products of the classes set out below, and extras, allowances and rebates, shall be those provided for in or calculated in accordance with the Related Schedules.

IRON ORE—

All prices are f.o.t. at quarry or mine.

	£ s. d.
Hematite :	
(*a*) For use in blast-furnaces, mined in the counties of Cumberland, Lancashire, and Glamorgan	1 6 3
(*b*) Lumpy, for use in steel furnaces	2 2 0
Jurassic :	
(*a*) Quarried or mined in the Frodingham district of Lincolnshire	3 9
(*b*) Quarried in Oxfordshire	3 0
(*c*) Quarried or mined in Leicestershire, Northamptonshire, Rutland, or Lincolnshire (other than provided for under (*a*)) with an iron content as produced exceeding 34 per cent.	4 6
(*d*) Quarried or mined in Leicestershire, Northamptonshire, Rutland, or Lincolnshire, other than provided for under (*a*) and (*c*)	4 0
Calcined :	
(*a*) Quarried in Oxfordshire	7 0
(*b*) Quarried or mined in Leicestershire, Northamptonshire, Rutland, or Lincolnshire...	8 6
(*c*) North Staffordshire Coal Measure	1 11 0

FERRO-ALLOYS AND ALLIED MATERIALS—

Ferro-Molybdenum and Molyte, 6s. per lb. of molybdenum content

Calcium Molybdate, 5s. 9d. per lb. of Molybdenum content

Ferro-Tungsten, 5s. 1d. per lb. of Tungsten content 98/99 per cent. Tungsten Powder, 5s. 2½d. per lb.

Ferro-Vanadium, 15s. 6d. per lb. of Vanadium content

CINDER AND SCALE—

	£ s. d.
(*a*) Good Clean Scale for use in open-hearth steel furnaces, f.o.t., producing works	1 4 0
(*b*) Scale for use in blast-furnaces or sintering plants	1 5 6
(*c*) Ball Furnace Cinder containing not less than 68 per cent. iron for use in blast-furnaces ...	1 8 0
(*d*) All other Cinder for use in blast-furnaces ...	1 3 0

PIG IRON—

	£ s. d.
Basic—delivered station or siding to :	
(*a*) South Wales, N.E. Coast, Scotland, Mersey Ports, Lancashire, Cheshire, N. Wales, North Staffs, and Yorkshire (including Sheffield) ...	6 0 6
(*b*) South Staffordshire and all other districts ...	6 3 0
Hematite—No. 1 Mixed Nos., S. & P. over 0·03 per cent., but not exceeding 0·05 per cent.—delivered station or siding to :	
(*a*) Scotland, N.E. Coast, and West Coast England	6 18 6
(*b*) Sheffield...	7 4 0
(*c*) Birmingham	7 10 0
(*d*) Wales—Welsh Iron	6 14 0
Foundry and Forge—delivered station or siding :	
(*a*) No. 3 Iron, Class 2—	
(1) Middlesbrough	6 8 0
(2) Birmingham	6 10 0
(*b*) Phosphorus over 0·50 per cent. to 0·75 per cent.—Birmingham...	6 17 6
(*c*) Phosphorus over 0·10 per cent. to 0·50 per cent.—Birmingham...	7 0 6
(*d*) Scotch No. 3 Foundry Iron—delivered Grangemouth	6 4 9
Cylinder and Refined :	
(*a*) North Zone	8 14 0
(*b*) South Zone	8 16 6
Refined Malleable :	
Birmingham and South Staffordshire	8 11 6
Cold Blast :	
South Staffordshire	11 7 6
Blast-furnace Ferro-Manganese :	
76 per cent. to 80 per cent. Mn. Standard Grade ...	18 10 0

FORGING INGOTS—

	£ s. d.
Up to 0·60 per cent. C	13 1 6

BILLETS, BLOOMS, AND SLABS FOR RE-ROLLING—

	£ s. d.
Basic :	
(*a*) Soft U.T. (100-ton lots)	12 5 0
(*b*) Soft T.G. up to 0·25 per cent. C (100-ton lots)...	12 10 0
(*c*) Hard 0·42 per cent. to 0·60 per cent. C	13 17 6
(*d*) Silico-Manganese	16 5 0
(*e*) Free-cutting	14 10 0
Siemens Martin Acid :	
(*a*) Up to 0·25 per cent. C	15 15 0
(*b*) Case-hardening	16 12 6
(*c*) Silico-Manganese	16 5 0

BILLETS, BLOOMS, AND SLABS FOR FORGING, DROP FORGING AND STAMPING—

	£ s. d.
Basic :	
(*a*) Soft, up to 0·25 per cent. C...	13 17 6
(*b*) Hard, over 0·41 per cent. to 0·60 per cent. C...	14 10 0
Acid :	
(*a*) Up to 0·25 per cent. C	16 5 0
(*b*) Case hardening	17 2 6
(*c*) Silico-Manganese	16 15 0

ALLOY STEELS—

	0·6–1 per cent. Nickel.	Nickel-Chrome Ni 2·75–3·75 Cr 0·6–1·25 per cent.	Nickel-Chrome Molybdenum Ni 2·75–3·75 Cr 0·60–1·25 Mo 0·20–0·60 per cent.
	£ s. d.	£ s. d.	£ s. d.
Billets, 2in. up to and including 10in.	19 0 0	30 17 6	37 13 6
Stamping Bars, ¾in. dia. and up, round or equivalent sectional area	26 7 6	39 12 6	47 11 6

STAINLESS STEEL AND IRON—

	Austenitic.	*Martensitic.*
Steel Billets, 2in. and larger, square and gothic sections	1s. per lb.	8½d. per lb.

SHELL STEEL—

	£ s. d.
Rounds, Squares, Gothic Billets, or other Similar Sections—3in. and up :	
Over 30 per cent. up to and including 0·60 per cent. Carbon	16 5 6

SHELL STEEL DISCARDS—

	£ s. d.
(*a*) *Shell Steel Discard Billets* where supplied in small sizes, 2in., 3in., and 4in. square, or rolled to the finished Shell Steel size, which can be rolled direct by the re-roller	12 5 0
(*b*) *Other Discards in the shape of Billets, Blooms, or Slabs* requiring further processing before capable of being rolled into standard sizes of billets for the re-rollers	10 5 0

HIGH-SPEED STEEL—

	14 per cent. Tungsten, per lb.	18 per cent. Tungsten, per lb.	22 per cent. Tungsten, per lb.
	s. d.	s. d.	s. d.
Bars	3 0	3 10	4 4

TIN-PLATE AND SHEET BARS—

	£ s. d.
Delivered station or siding in not less than 6-ton lots	12 2 6

WIRE RODS—

	£ s. d.
Basic.—All sizes with exception of 6 gauge and over 7/0 gauge delivered in all districts in United Kingdom except (*a*) Birmingham and Scotland, and (*b*) Southern Joint Area :	
Soft Basic 0·08 per cent. to 0·25 per cent. C ...	17 7 6
Hard Basic 0·42 per cent. to 0·60 per cent. C ...	21 2 6
Free-cutting...	20 2 6
Acid.—Up to 0·85 per cent. C all sizes, with exception of 6 gauge and over 7/0 gauge, delivered all districts :	
Ordinary	24 13 6

MANUFACTURED IRON—

	Crown Iron.	No. 3 Bars.	No. 4 Bars.
	£ s. d.	£ s. d.	£ s. d.
(*a*) English and Welsh delivery, usual districts	15 12 6	12 10 0	13 0 0
(*b*) Scottish delivery, station or siding, usual districts	15 12 6	13 12 6	13 17 6
(*c*) Irish delivery, f.o.q. Belfast	16 5 0	13 2 6	13 12 6

HEAVY STEEL PRODUCTS—

	Joists and Angles.	Plates.	Boiler Plates.
	£ s. d.	£ s. d.	£ s. d.
Deliveries to the following Principal Districts :			
(*a*) North-East Coast, Northern Joint Area, Scotland, Belfast shipyards and shipbuilders at Thorne, New Holland and Gainsborough	15 8 0	16 3 0	17 0 6
(*b*) Leeds and District, Midland Area, and South Wales	15 8 0	16 5 6	17 3 0
(*c*) Southern Joint Area ...	15 10 6	16 8 0	17 5 6
(*d*) f.o.q. Belfast (other than shipyards)	15 13 0	16 8 0	17 5 6
Medium Plates (under ¾in. thick) all deliveries—			
Weighing 6 lb. or more per sq. ft.			17 17 6
Weighing less than 6 lb., but not less than 4·81 lb. per sq. ft.			18 7 6
Chequered Plates (¼in. thick and upwards) delivered to :			
(*a*) North-East Coast and shipbuilders at Thorne, New Holland, and Gainsborough			17 13 0
(*b*) Northern Joint Area, Scotland, Leeds and District, Midlands and South Wales, Southern Joint Area...			17 15 6

RAILS—

	£ s. d.
Heavy Rails.—60 lb. per yard and over, lots of 500 tons and over ; f.o.t. makers' works	14 10 6
Light Rails.—Light flange rails, up to and including 25 lb. per yard	16 15 0

COLLIERY ARCHES AND ACCESSORIES—

	£ s. d.
4in. by 2½in. by 2in. and 4in. by 2½in. by 2½in., single radius, with straight horseshoe or splayed legs with one fish-plate joint, complete with one pair of fish-plates and the necessary bolts and nuts	17 6 6
Arches as above, but *without* fish-plates, bolts and nuts	17 4 0
Fish-plates (for Arches) alone	22 8 0
Plain Cambered Girders, 4in. by 2½in. by 2in. and 4in. by 2½in. by 2½in., with minimum camber of 2in. in centre, for use underground only	16 19 0
Corrugated Straps, Roofing, or Benk Bars	16 0 6

RE-ROLLED STEEL PRODUCTS—

	£ s. d.
Angles and Tees, 4 united inches and under, and *Channels* 3in. web and under :	
Basis U.T.	17 2 0
Bars—Flats, 5in. wide and under, and *Rounds and Squares* under 3in. U.T....	17 12 0
Free-cutting Bars—Rounds	19 16 6
Hoop and Strip—hot rolled (excluding hoop and strip for Gas, Steam, and Water Tubes, (U.T.) ...	18 7 0
Hoop and Strip—cold rolled. Hard Bright—in coils (not annealed)—1½in. to 6in. by 0·032in. and thicker	26 2 9
Products made from Basic Hard Steel—0·42 per cent. to 0·60 per cent. C...	19 5 0
Products made from Siemens Martin Acid Steel—Up to 0·25 per cent. C...	21 2 6
Spring Steel Bars—Laminated :	
(*a*) Basic 0·42 per cent. to 0·60 per cent. C, Water Hardening	19 5 0
(*b*) Acid 0·42 per cent. to 0·60 per cent. C, Water Hardening	22 16 0
Siemens Martin File Steel—Long lengths, 12in. and up :	
(*a*) Acid	24 7 6
(*b*) Basic	21 14 6
Ferro-Concrete Bars—delivered station or siding ...	16 19 6
Rivet, Bolt and Nut Bars (4-ton lots)	17 15 0

RE-ROLLED STEEL PRODUCTS (*continued*)—

	£	s.	d.
Glazing Tees—Special Glazing Bulb or long-stalked Tees	21	5	0
Sash and Casement Sections—Main Standard Cottage Zeds	20	18	0
Gate Channels	19	16	0

BRIGHT STEEL—

Bars :			
(*a*) Mild steel to no analysis or tests	24	14	0
(*b*) Tested and guaranteed, 28 tons to 32 tons tensile	25	14	0
(*c*) Free-cutting B.S.S. 32, Grade 4	27	7	0
Flats—not tested or guaranteed	34	9	0

SHEETS—

Black—24 g. (4 tons and over of basis quality)	22	15	0
Galvanised—Corrugated, 24 g. (4 tons and over of basis quality)	26	2	6

TIN-PLATE, TERNE-PLATE AND BLACK-PLATE—

Tin-plate—Coke quality, per basis box (I.C. 20 by 14, 112 sheets, 108 lb.), f.o.t. Makers' works	1	9	9
Terne-plate—Unassorted Light Ternes ordinary quality sold per basis box (28 by 20, 112 sheets, 216 lb.), f.o.t. Makers' works	2	15	9
Black-plate—Rectangles, unassorted, C.A. quality, 28/14 b.g., per ton f.o.t. Makers' works	22	14	9

TUBES, PIPES AND FITTINGS—

Gas List Wrought Iron and Steel Tubes and Fittings.
Loose Flange Joint Tubes.
Wrought Iron and Hot Finished Steel Boiler Tubes.
Steel Pipes to B.S.S. 534. *Table* 1.
A.P.I. Line Pipe.
Malleable Pipe Fittings.
Steel Conduit Tubes.
Vertically Cast Iron Pipes and Spun Iron Pipes.
Standard Socket and Spigot Special Castings.
Cast Iron Drain Pipes.
Cast Iron Drain Pipe Fittings.
Angle Cast Iron Pipes for Gas and Water Purposes.

The prices stated in the Standard Lists and Related Schedules less any discounts provided for in the Related Schedules.

WIRE AND WIRE PRODUCTS—

	£	s.	d.
Mild Steel Wire—Catch weight coils 6/8 standard wire gauge for sales by Makers in 2-ton lots :			
Hard drawn	22	5	0
Mild drawn	23	15	0
Annealed	23	15	0
Galvanised Barbed Wire—2 or 4 point, 2 ply, 12½ gauge for sale by Makers in 2-ton lots	31	5	0

FORGINGS—

Prices set out in the Related Schedules, plus the percentage additions in operation at October 31st, 1940, plus in the case of Related Schedule No. 255, 4 per centum, and in the case of Related Schedules Nos. 256 and 257, 10 per centum.

STEEL CASTINGS—

Prices set out in the Related Schedules with the addition of 9 per cent., plus 25s. per ton.

RAILWAY TYRES, AXLES, SOLID WHEELS AND STANDARD TYPES OF COMPLETE WHEELS AND AXLES—

Prices set out in the Related Schedules, plus £2 2s. 6d. per ton.

RAILWAY COIL SPRINGS—

		£	s.	d.
Spiral Buffer and Draw Springs :				
R.C.H. Drawing No. 209 A/1	each	0	11	2
R.C.H. Drawing No. 209 A/2	each	1	6	3
Volute Buffer and Draw Springs :				
R.C.H. Drawing No. 209 A/8	each	0	12	11

LAMINATED RAILWAY SPRINGS—

Bearing Springs—5 plate ordinary wagon, 4in. wide by ⅜in. plates	33	14	0
Buffing Springs—14 plate, with double double lug hoops	35	11	6

IRON CASTINGS—

For rainwater and Soil Goods, Gutters and Connections—the prices set out in the Related Schedules, with the addition of 18¼ per centum.

RIVETS—

4in. by ⅜in. diameter—2-ton lots, ex-works, delivered Midland Area :

Mild Steel	22	15	0
Wrought Iron	20	0	0

THE DOXFORD CENTENARY

IN the course of his speech at the forty-eighth annual ordinary general meeting of William Doxford and Sons, Ltd., Dr. E. P. Andreae, the chairman of the company, said that it was fitting that this year's meeting should be held at Sunderland, for it was on the banks of the Wear, just a hundred years ago, that William Doxford commenced business as a shipbuilder. The original shipyard was built on the upper reaches of the river, where wooden coasting vessels were constructed. Seventeen years later the present site at Pallion was acquired, and it was at these works that the founder and his sons developed the business from small beginnings, into a prosperous enterprise, known and highly respected in shipping circles the world over. Dr. Andreae remarked that he thought that he was right in saying that the keynotes of their success were individual progressive effort, a keen appreciation of modern developments, and the courage to back their opinion. The successors of the Doxford family in the administration of this great enterprise looked back with pride upon its past history of enlightened development, and it would be their task to guard the reputation and to maintain the tradition which had so long been associated with the name of William Doxford and Sons, Ltd. Dr. Andreae concluded by saying that he could not give any information as to the output of the firm or the work in progress. The extensions to the works had now been completed and were in operation, and it might be taken for granted that whilst war conditions lasted the company would continue to be fully occupied with work of national importance.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer

Iron and Steel Price Advances

The Minister of Supply has made the Control of Iron and Steel (No. 13) Order, 1940, which came into force on November 1st. Under this Order new maximum prices for iron and steel products are instituted and those laid down in the Control of Iron and Steel (No. 8) Order, as amended by Nos. 10, 11, and 12 Orders, are withdrawn. The new maximum prices fixed under the Order represent an increase of 35s. a ton on billets, sections, joists, and rails, and of £2 a ton on plates, with corresponding adjustments in the prices of finished products such as tubes, bolts and nuts, and wire. The greater part of these advances in price, as in the case of advances previously made since the beginning of the war, is to meet payments into a Central Fund which is used to equalise the cost of imported steel and raw materials with the price of similar home products. In particular, the need to augment the Central Fund is the result of the increasing quantities of imported steel now arriving from the United States. Some allowance, amounting to about 5 per cent. on present prices, has been made to meet certain increases in home production costs. In addition to the prices mentioned above, the quotations for pig iron have been advanced from 6s. to 8s. per ton, and for alloy steels by £1 10s. to £2 10s. Wire rod prices have been increased by £2 3s. 6d. to £2 10s. There have been substantial advances in the prices of sheets and for 24 g. blacks in 4-ton lots the price is now £22 15s., an increase of £2 7s. 6d., whilst for galvanised corrugated sheets, 24 g. basis in 4-ton lots, there is a rise of £3 10s. to £26 2s. 6d. Coke tin-plates have been advanced by 3s. 9d. per basis box to £1 9s. 9d. f.o.t.

The Pig Iron Market

The effect of the new Control of Iron and Steel (No. 13) Order upon the pig iron position has been to advance quotations by 6s. to 8s. per ton. The upward movement in price, however, is not likely to have any influence upon the demand. So much of the present production of pig iron is required by firms engaged upon Government work that there is little surplus in any case for pig iron for non-essential purposes. The volume of business in this market, therefore, is likely to be maintained at recent levels. So far as deliveries are concerned the position is satisfactory, and in no department is there any severe stringency, although, in some instances, consumers have to make do with pig iron of a quality which they would not consider using in peace time. The output of high-phosphoric pig iron is sufficient to meet all the demands made upon it, and if, as is expected, there is an expansion in the requirements of the light castings industry as more firms are given Government contracts, it is unlikely to place any strain upon the available supplies. There is not so much freedom in the low-phosphoric foundry iron situation, and considerable quantities of this description are passing into consumption, as it is required on an important scale by machine tool makers and motor vehicle manufacturers. The pressure recently was severe and there was a definite stringency in the market; but the Control has met the position by imports of the necessary quality pig iron and it is understood that further quantities are expected to arrive in this country. The demand for hematite is unabated, and here, again, if it were not for the imports arranged by the Control the situation would be tight. Deliveries of imported iron, however, have been made recently in directions in which the requirements were most urgent, and any inconvenience which has been experienced by consumers needing hematite seems to have been overcome. The quotation for East Coast hematite, No. 1, is now £6 18s. 6d. d/d Scotland, North-East Coast, and West Coast of England, with a loyalty rebate of 5s. The former price of £6 11s. was well below the landed price of foreign hematite, and this naturally had a considerable influence upon the decision to raise the quotation.

The North-East Coast and Yorkshire

The comprehensive price advance covering practically all ranges of iron and steel materials has had no effect upon the market. The movement had been expected for several weeks and recent contracts have been entered into upon terms providing that the prices should be those ruling on the date of delivery. A large proportion of the production is absorbed in the satisfaction of priority orders and there is not likely to be any decline in the volume of manufactured steel required for essential national purposes. An advance of £1 15s. to £2 in the price of joists, angles and plates may have been rather more than had been expected, but consumers' requirements of these are heavy and in the few days which have elapsed since the order was published there has been no sign of any slackening in the demand. The constructional engineers may not be so busy as they were some weeks ago, but they are still taking large tonnages of structural steel, and the shipyards run them close in the weight of their requirements. The sheet mills have maintained large outputs for a long period and the greater part of their production is earmarked for Service requirements. An advance of £2 7s. 6d. basis on black sheets and of £3 10s. basis on corrugated galvanised sheets may have come as a surprise to the market, which was perhaps scarcely prepared for such a substantial rise. Comparatively small quantities of sheets, however, have been obtainable either for export or for home non-essential needs, and as the works already have orders in hand sufficient to keep them busy for some months the situation is not likely to be affected by the advance. The Yorkshire steel industry has been operating at capacity. In Sheffield the steel works have been well supplied with raw materials and the melting plants have been working at full time. Large outputs have been attained and it is claimed that there is a tendency for them to increase. The effort to expand the export trade has resulted in a considerable volume of orders reaching the Sheffield steel makers, and a certain amount of precedence is given this work where possible. Although the call is principally for basic steel material, the producers of acid carbon steel report full order books and an insistent demand. Alloy and special steels are also being produced in considerable tonnages and are passing immediately into consumption.

Copper and Tin

Whilst the position of copper in Great Britain presents no fresh characteristics from those which have been apparent for many weeks, the situation in the United States seems to be getting rather tight. So far as Great Britain is concerned, the Non-ferrous Metal Control appears to be handling the situation satisfactorily, and consumers are obtaining all their requirements. Supplies are coming to hand with regularity and freedom, and they have not much to worry about. Consumption is on an exceedingly heavy scale, and is likely to remain so, probably for the duration of the war. As to the statistical position in this country, it is, of course, impossible to say, since no figures are published; but so far as can be judged the situation is comfortable. In the United States there has been a tendency for prices to ease and the export quotation is now 10·25c. f.a.s., although the domestic price is held at 12c. For the time being the American market has been overshadowed by the Presidential election. The demand appears to have been well maintained; producers are not anxious sellers, and the position is sufficiently tight to necessitate a form of rationing by allocating definite quantities of copper to consumers. There is still talk of allowing copper to be imported duty free into the United States for a time, and it is suggested that if this policy were adopted imports would be limited to 10,000 tons per month. The view is held that in the present emergency it would be unwise for the American Government to permit stocks of copper to become exhausted or materially reduced, and that copper should be brought in duty free to be used on Government contracts. . . . The tin market has shown a tendency for prices to become easier. United States buying has not developed to the extent which was expected and as a result there has been less covering on the Metal Exchange, whilst smelters have been selling fair quantities. As a result of the issue of export licences, a certain amount of tin has been exported, but the stocks in Great Britain are understood to be at a comfortable level. The contango stands at about £2 10s., which may be regarded as normal. There is a movement afoot to approach the Government to have tin included in the war risks insurance scheme, since there is naturally a certain amount of reluctance by dealers to hold metal in the present conditions. If this were done it would almost certainly mean that the price would advance a little. It is not expected that values will recede to any important extent; but on the other hand there is no indication of an upward movement. It is suggested that if Bolivian supplies of concentrates are diverted to the United States it may have the effect of raising the British price to the world level.

Lead and Spelter

Large quantities of lead are being used in this country, chiefly by firms engaged upon armament work. The supplies, however, have been adequate to meet all calls and there seems little doubt that the situation is satisfactory. In the United States the demand for lead is moderate, but the producers appear to be well sold, and are showing no anxiety to obtain business. Export licences appear to be obtainable from the British Non-ferrous Metal Control with a certain amount of freedom, and manufacturers of lead products for export find no difficulty in obtaining metal they need. According to the report of the United States Bureau of Mines, Hong Kong Mines, Ltd., during 1939 produced 5785 short tons of lead concentrates of 65 per cent. It was expected that in the early months of 1940 this output would be increased. At the end of June this year the stocks were calculated at 7000 tons, of which 5000 tons had been sold to Great Britain. . . . Whilst consumers of spelter in this country who are engaged upon national work can obtain all the spelter they need, it is not easy for firms employed upon work which does not come within this category to obtain licences. In the United States the position has grown rather stringent. Indian buyers have been in the market, and a good many of their orders have come to London, but it has been found difficult to obtain the spelter in the United States. In fact, it has been suggested in that country that spelter should be sent there from Canada to complete British orders for manufactured products.

Non-ferrous Metal Prices

The London Metal Exchange statement for October shows a substantial rise in the average price of tin. Compared with the previous month the settlement price advanced by £6 15s. 5d. to £258 2s. 9d., whilst for cash tin the average was £6 16s. 2d. up at £258 3s. The average quotation for three months' metal was £260 10s. 3d., a rise of £6 5s. 8d. over the average for September. The statement, which includes the official maximum prices for copper, lead and spelter, is as follows:—

		£	s.	d.
Standard tin	Cash (mean)	£258	3	0 3/4
	Three months (mean)	£260	10	3 1/4
	Settlement	£258	2	9 3/4

The following prices for copper, lead and spelter are the maximum prices fixed by the Controller of Non-ferrous Metals:—

	£	s.	d.	
Standard copper				
Electrolytic copper	62	0	0	delivered buyers' premises
Electrolytic wire bars	62	0	0	,, ,,
Best selected copper	60	10	0	,, ,,
Lead, good soft pig (foreign)	25	0	0	,, ,, (duty paid)
Spelter, G.O.B. (foreign)	25	15	0	,, ,, (duty paid)

Notes and Memoranda

Rail and Road

UNDERGROUND RAILWAY FOR MELBOURNE.—The City Council of Melbourne has again asked the Railway Department of the State of Victoria to construct an underground line to relieve congestion in the northern part of the city.

NEW ZEALAND ELECTRIFICATION.—The change over from steam to electric traction on the Wellington-Paekakariki main line section is proceeding gradually. Since July certain of the principal expresses have been hauled by the English Electric type of 1–Do–1 locomotive. As many as fifteen passenger cars have been hauled.

REFRIGERATOR CARS FOR ORANGES.—A new type of refrigerator car has been designed and built by the Pacific Fruit Express Company at its Los Angeles shops. An ice bunker running the whole length of the roof is supplemented by refrigerating compartments fitted along both sides of the car. This arrangement allows of three tiers of boxes of fruit being stacked in each car, the capacity of which is thus doubled.

"CORONATION SCOT."—Following the closing down of the New York World's Fair, the L.M.S. Railway announces that its crack express train, the "Coronation Scot," which has been on exhibition there, has been visited by no fewer than 1,187,000 people. The "Coronation Scot" will shortly leave for Baltimore, where it will be stored in the shops of the Baltimore and Ohio Railroad until such time as it can be brought back to this country.

RAIL WELDING.—The welding of rails into long lengths is receiving much attention from railway engineers, and the London Passenger Transport Board, having decided to weld rails into lengths of up to 300ft., has equipped an up-to-date depot in which the welding and all other work connected with the treatment of the rails can be carried out with speed and economy. Not only is the welding of running rails and conductor rails up to 150-lb. section undertaken, but other work carried out at the depot is the grinding of the surface of rails which may have become corrugated.

A ROAD-MAKING EXPERIMENT.—The Chief Engineer of National Roads in Natal has begun to experiment at Ladysmith with soil cement for roads. This provides a cheap method of construction which, it is claimed, is an improvement on the ordinary macadamised road, while forming a solid bed to receive a bitumen coat. The road is first disc-harrowed, then earth is mixed with the correct quantity of cement and is spread on the top. When the mixture is levelled, water is sprayed on, to the right point of absorption, and the road rolled. About 3in. thickness of loose soil is finally spread on the top to permit of proper hardening. Each class of soil has to be analysed to determine the correct method of treatment.

GROWTH OF SOVIET RAILWAY SYSTEM.—The Soviet newspaper *Izvestia* publishes some interesting figures relating to the growth of the railway system in the U.S.S.R. since the establishment of the Soviet *régime*. From 1917 to 1937 over 9000 miles of new railways were built. The projected construction of railways under the Third Five-year Plan (1938–1942) includes 6835 miles of new lines and the double-tracking of 5000 miles of existing lines, an appreciable part of which work has already been completed. During the period of the Second Five-year Plan (1932–1937) the Soviet railways acquired 186,000 new wagons and over 6000 powerful locomotives. In July, 1935, the average daily loadings on the Soviet railways equalled 73,000 wagons. In July, 1940, the average daily loadings on the railways of the U.S.S.R. had risen to 108,000 wagons.

RAIL LUBRICATION.—Economies from the use of rail lubricators are the subject of a report presented at a convention of the American Railway Engineering Association. They relate to experiments made on the Denver and Salt Lake Railway, where fourteen mechanical lubricators have been installed between Utah Junction and the east portal of the Moffat tunnel, a distance of 45½ miles of severely curved line, which for the greater part of the distance has a gradient of 1 in 50 compensated for curvature. The total rise in 40 miles from the 5th mile post out of the Utah Junction to the Moffat tunnel is 3775ft. Tests were made before and after the lubricators were brought into action, and the net result was to establish that their effect was to reduce curve resistance about 50 per cent., and that the normal tonnage hauled up the gradient could be increased by 2·6 per cent.

Air and Water

DELAWARE RIVER DEEPENING.—To provide for the deepening of the Delaware River from the Navy Yard at Philadelphia to the Atlantic Ocean from 35ft. to 40ft., an appropriation of 4,250,000 dollars has been voted for the work, which has been begun. This work will make possible movement of the 45,000-ton battleships now being constructed at the Philadelphia yard.

MERCANTILE LOSSES.—Mercantile losses through enemy action for the week ended October 26th include six British ships amounting to 9986 tons, and two Allied ships amounting to 6874 tons. The total tonnage figure of 16,860 does not include the 42,348-ton "Empress of Britain," the loss of which has already been announced. Up to October 31st enemy mercantile losses were 325 ships, approximating 1,542,000 tons.

CANADIAN WATER POWER.—One of the largest engineering undertakings in Canada is nearing completion. The St. Maurice Power Corporation, jointly and equally owned by the Shawinigan Water and Power Company and Brown Corporation, expects shortly to start three 40,500 H.P. generating units, while a fourth should be ready by January, 1941. The scheme covers a fifth and sixth unit to be installed some time in the future. Construction was begun by the Shawinigan Engineering Company, Ltd., in March, 1937, and the work has been carried out in advance of schedule and within the original cost estimates. The chief engineer in charge of the construction and design is Mr. J. A. McCrory, until recently a vice-president of the Engineering Institute of Canada. The completion of the scheme means that an additional 162,000 H.P. of electrical energy will be available for the industrial areas of Quebec province.

A DAM OPENED.—The Hansen dam, the major unit of the 70-million-dollar Los Angeles county flood control system, has been inaugurated, more than a year ahead of schedule, December 7th, 1941, being the limit specified in the contract. It is a rolled-earth structure, horse-shoe in shape, with a length of 3500 yards and a maximum height above stream bed of 122ft. The thickness of the base is 1139ft. and a total of 14,000,000 cubic yards of earth was used in compacting the fill. The dam will regulate the flow of Big and Little Tujunga Washes, the flow from which was one of the major causes of disaster in the flood of March, 1938, on the Los Angeles River.

WORLD'S LARGEST DRYDOCK.—In 1938 there was constructed in the Upper New York Bay a dock, known as the Bayonne terminal, at a cost of about 4,300,000 dollars, of which 2,530,000 dollars was covered by bonds issued by the city and the remainder was a federal grant. The city now proposes to sell the terminal to the Federal Government for the amount of its bond issue, and a supplemental defence appropriation Bill, recently approved by the Appropriations Committee of the House, will provide the Navy with funds to start construction of a supply depot and of a drydock large enough to accommodate the 45,000-ton battleships now being built.

Miscellanea

PROSPECTING IN BRAZIL.—The Department of Mineral Production of Brazil is trying to extend the mining of gold in Brazil, and in various parts of the country tests are being made to determine more exactly the location and extent of gold deposits. Much prospecting is being done in the states of Sao Paulo, Paraná, and Matto Grosso.

ELECTRICITY IN AGRICULTURE.—Progress in farm applications of electricity was a feature at a recent joint meeting of the North Atlantic Section of the American Society of Agricultural Engineers and the New England Rural Electrification Institute at the University of Maine, Orono, when the agenda included three sessions on rural electrification.

CANADIAN STEEL.—Canadian steel ingot production is working to capacity. Output for August was 166,879 tons, an increase of 2300 tons over July and 40·6 per cent. in excess of a year ago, when output was 118,784 tons. The highest for any month in the history of the industry was last May's production of 168,703 tons. For the first eight months of the year production of steel ingots in Canada totalled 1,251,942 tons.

TIN IMPORT LICENCES.—In future, licences to import tin metal and alloys containing more than 50 per cent. of tin will be issued on the advice of the Non-ferrous Metals Control. Forms of application may be obtained from the Import Licensing Department or the office of any Collector of H.M. Customs and Excise. An open general licence is in being for the import of tin in blocks, slabs, ingots, and bars from the British Empire, except Palestine, Hong Kong, and Transjordan.

ROOF SPOTTING CLASSES.—The Ministry of Home Security announces that classes have now been established for training in roof spotting at over 100 centres in different parts of the country. In order to cover the whole of industry as quickly as possible, it is intended to allot vacancies to one representative of each firm desiring training; this representative will then be in a position to train the roof spotting team of his firm. Courses will last five days. Firms desiring training should apply to their local A.R.P. Controller, whose address can be obtained from the Town or County Hall or from the local Council offices. Full particulars of the arrangements will be supplied and vacancies allotted at the earliest possible moment.

LIFT HANDBOOK.—Marryat and Scott, Ltd., of 75, Clerkenwell Road, London, E.C.1, have produced a "Lift Handbook," which deals with the question of lift maintenance from a somewhat new aspect. The author, Mr. L. J. Gooch, A.M.I.E.E., commences with a brief general description of an electric lift and then proceeds to trace the historical developments of the controller in such a way that the main principles underlying lift control can be assimilated by anyone having only elementary electrical knowledge. Many illustrations are given and the explanation of the lift control circuit from the simplest form of hand rope control to attendant operated and automatic systems is distinctly novel. The second half of the book is devoted to maintenance and the slogan is that of "Safety First," so that if the instructions are followed, anyone not versed in lift practice should be able to give ordinary maintenance attention to a lift without harming themselves or the machine. The section dealing with the tracing of troubles contains a number of charts, by the use of which the more usual defects causing lift stoppages can be found by a process of elimination and rectified.

Personal and Business

SIR CLIVE BAILLIEU has been elected chairman of the Imperial Smelting Corporation, Ltd., and Mr. L. B. Robinson has been appointed to a seat on the board.

CHANGE OF ADDRESS.—Wellworthy Piston Rings, Ltd., has removed its service depot at 143, Suffolk Street, Birmingham, W.1, to Somerset House, Temple Street, Birmingham, 1.

COX AND DANKS, Ltd., inform us that their registered office and accounts department has been temporarily transferred from Park Royal, London, to The Grove, Rainbow Hill, Worcester.

LT.-COLONEL J. T. C. MOORE-BRABAZON has resigned his position as director and chairman of the board of Briggs Motor Bodies, Ltd., on his recent appointment as Minister of Transport.

THE GLOUCESTER RAILWAY CARRIAGE AND WAGON COMPANY, Ltd., has removed its London office to 4, Chelsea Court, Chelsea Embankment, London, S.W.3. Telephone number, Flaxman 6637.

MR. J. G. BULGER has resigned from the Light Alloy Control (Castings) to take up a more senior position with the Ministry of Labour and National Service, Montague House, Whitehall, S.W.1.

MR. J. V. GIL, M.I.E.E., is resigning his position of technical director to the Kohler Company, Ltd., and has been appointed (as from December 2nd) chief electrical engineer to F. Perkins, Ltd., of Peterborough. The production of British-made automatic generating plants, embodying the Perkins diesel engine, will now be continued by F. Perkins, Ltd.

THE LATE MR. H. T. TILLEY.—We regret to announce the death on October 28th of Mr. H. T. Tilley, manager of the London engineering department of the General Electric Company, Ltd. He was fifty-three years of age. Mr. Tilley joined the G.E.C. thirty years ago and for the greater part of that period was chief assistant to the late Mr. J. Mercer, after whose death in March last he succeeded as manager.

COLONIAL OFFICE PROMOTIONS.—The Colonial Office has announced the following promotions:—Mr. E. R. Masters, Senior Locomotive Superintendent, Gold Coast Railway, to be Chief Mechanical Engineer, Palestine Railways; Mr. W. Venner, District Locomotive Superintendent, Gold Coast Railway, to be Chief Mechanical Engineer, Sierra Leone Government Railways; and Mr. H. W. Winson, Principal Assistant to the Chief Accountant, Nigerian Railway, to be Chief Accountant, Gold Coast Railway.

HADFIELDS LTD. inform us that Mr. P. B. Brown, J.P., M. Inst. C.E., has been appointed chairman in succession to the late Sir R. A. Hadfield, Bt., and Major A. B. H. Clerke, C.B.E., late R.A., appointed to succeed Mr. P. B. Brown as deputy chairman. Mr. P. B. Brown joined the company in the year of its formation, 1888, was appointed a director in 1909, a managing director in 1917, becoming deputy chairman in 1930. Major Clerke joined the company in 1911, was elected a director in 1913 and a managing director in 1917.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Bradford Engineering Society

Monday, Nov. 11th.—Technical College, Bradford. "Fine Measurement," J. G. Jagger. 7.15 p.m.

Institute of Transport

Saturday, Nov. 9th.—METROPOLITAN GRADUATES: Inst. of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. "Trolleybuses in London," E. C. V. Jubb. 3 p.m.

Institution of Automobile Engineers

Saturday, Nov. 9th.—LONDON GRADUATES: 12, Hobart Place, S.W.1. "The Post-war Automobile," G. Roesch. 3 p.m.

Thursday, Nov. 14th.—LEEDS GRADUATES: Hotel Metropole, Leeds. "Lubrication, with Special Reference to Gear Lubrication," H. J. Watson. 7.30 p.m.

Tuesday, Nov. 26th.—BIRMINGHAM CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham. "Notes on Filtration and Distribution of Lubricating Oil," T. C. Worth. 7 p.m.

Friday, Nov. 29th.—BIRMINGHAM GRADUATES: James Watt Memorial Institute, Great Charles Street, Birmingham. "Balancing in Automobile Engineering," G. D. Campbell. 7 p.m.

Institution of Electrical Engineers

Saturday, Nov. 9th.—N. MIDLAND CENTRE: Hotel Metropole, Leeds. "The High-rupturing-capacity Cartridge Fuse, with Special Reference to Short-circuit Performance," J. W. Gibson. 2.30 p.m.

Institution of Engineers and Shipbuilders in Scotland

Tuesday, Nov. 12th.—39, Elmbank Crescent, Glasgow. "Automatic Control for Land and Marine Boilers," J. E. O'Breen. 6.30 p.m.

Junior Institution of Engineers

Saturday, Nov. 9th.—MIDLAND SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham. "Air Raid Shelters, Their Construction and Ventilation," C. M. Walter. 3 p.m.

Saturday, Nov. 16th.—39, Victoria Street, S.W.1. Annual General Meeting. 1.30 p.m.

Saturday, Nov. 30th.—39, Victoria Street, S.W.1. "Tide Mills in England and Wales," R. Wailes. 2.30 p.m.

Manchester Association of Engineers

Saturday, Nov. 9th.—Engineers' Club, Albert Square, Manchester. "Temperature Determination on Moving Machine Parts," H. Wright Baker. 2.30 p.m.

Saturday, Nov. 23rd.—Engineers' Club, Albert Square, Manchester. "Line Production of Machine Tools," O. Rendell. 2.30 p.m.

Newcomen Society

Wednesday, Nov. 13th.—Iron and Steel Institute, 4, Grosvenor Gardens, S.W.1. Annual general meeting. Presidential Address, C. E. Davies; "Primitive Iron Smelting, Part II: Eastern Steel Making Processes," E. W. Hulme; and "Henry Cort's Bicentenary," H. W. Dickinson. 2.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Friday, Nov. 15th.—Mining Institute, Newcastle-upon-Tyne. "Vibration Patterns of Propeller Blades," G. S. Baker. 6 p.m.

Royal Society of Arts

Wednesday, Nov. 13th.—John Adam Street, Adelphi, W.C.2. "Some Problems of War-time Labour Management," K. G. Fenelon. 1.45 p.m.